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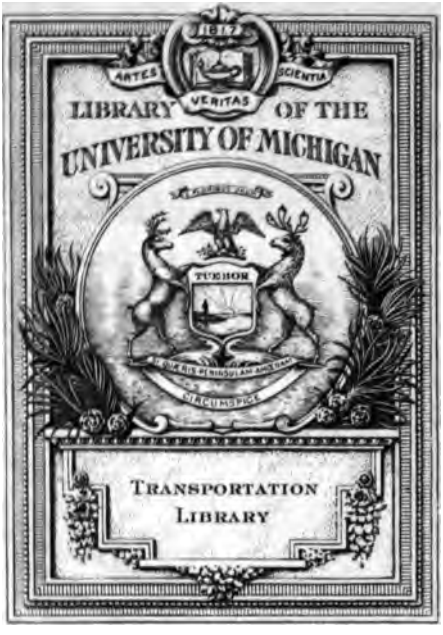
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THE

STEAM ENGINE,

FROM THE EARLIEST TO THE PRESENT TIME.

ATMOSPHERIC RAILWAYS—THE ELECTRIC PRINTING TELEGRAPH, AND SCREW PROPELLER.

BY EDWARD PORTWINE,

EDITOR OF "CARPENTER'S HELPS TO MEMORY," &c., &c., &c.

WOOD ENGRAVINGS, BY E. WILLIAMS.

Second Edition, Enlarged and Corrected.

LONDON:
E. APPLEYARD, 86, FARRINGDON STREET;
AND ALL BOOKSELLERS.
1847.

DEDICATION.

TO ALEXANDER SMITH, ENGINEER,

(*Croydon Atmospheric.*)

My Dear Sir—Perhaps I am the first person who ever dedicated a work to a Practical Mechanic. Rank and wealth are generally selected.

I estimate intellectual attainments and a love of science, far above titled ignorance or presumptuous wealth.

The qualities you possess—as honorable as they are rare—your ardent desire for the progression of science—induces me to inscribe this book to you.

And may that friendship, which we have reciprocated, continue, until old age has covered our temples with the frosts of many winters, or until the principle of Atmospheric Traction, for which we have contended, is added to the list of proved sciences.

I am, my dear Sir,

Yours very truly,

Edward Portwine.

Snow's Fields Factory,
Bermondsey.

PREFACE.

If the reader of this volume derives half the pleasure in its perusal that the composer experienced in writing it, the end for which he laboured will be attained.

It is an extraordinary fact, that in this age when knowledge is so easily obtained, so much ignorance is displayed by individuals who it is presumed ought to be well informed.

Stand on the deck of a steam-boat—rush through space propelled by steam or atmospheric pressure—gaze on the mysterious electric printing telegraph, or witness the beautiful evolutions of a screw vessel—have a thousand companions with you, and how many will you find that can inform you the variety of steam engine you are propelled by. Atmospheric pressure, electricity, and the operations of the screw, are all inexplicable to the vast majority.

This want of information has frequently caused us pain, and induced in our hearts a determination to publish a manual, which the scientific and the masses could easily understand: we have avoided

all technicalities, although we have a sufficient regard for science; and in producing this volume we have relied on practical information, without rejecting theory—for there are, and always will be—theorists to conceive—mechanics to execute.

We hope that all readers of this work, will rise from it, impressed with an opinion that there are facts contained in it, which have been worth the time consumed in its perusal—and that there is information useful and delightful, which will render them fit members of any society, whether it be in the saloons of our elegant steam boats—our crowded railway carriages, or in the commodious departments of our multitudinous stations.

This little book will recal to some the dim remembrance of their past struggles for the interests of science—while it may, for the first time, awaken in the hearts of others, a lively determination to remain no longer in ignorance—preferring the everlasting operations of nature and art to that fleeting literature which leaves no good impression on the mind.

EDWARD PORTWINE.

THE STEAM ENGINE.

CHAPTER I.

Before the Christian era, the force of steam was known. Hero, a learned mechanician, who wrote 130 years before the Christian era, invented a "toy," which he called the Æolipile. He was acquainted with the properties of the forcing pump, invented by Cetesibius. He also invented an excellent contrivance for an artificial fountain—a machine for producing a rotatory motion by a jet of heated air. This is still called "Hero's Fountain." This philosopher also invented many other mechanical instruments. The Æolipile consists of a globular metallic vessel, with tubes revolving on two pivots.

Barker's Mill is on the same principle as the Æolipile; and although it has not lately been made use of, yet it exhibits motion produced by the force of steam. It is a simple contrivance. Avery, the American engineer, proposed it as a moving power. The machine by Hero, for raising water by the sun's rays on the air, in a globe two-thirds full of water, the air expanding, and pressing the water through a tube, was ineffective, as it would only raise a few drops of that element; therefore, to raise water from mines to the re-

quired height, it was considered to be useless. Yet this was the first intimation on record of a moving power, which has been so much improved by modern science. Hero caused wine to flow from the hands of effigies set beside an altar, after the fire upon the altar had been lighted. A steam-tight vessel, or vase, containing wine, was placed within each effigy, and the altar made hollow, and partly filled with water, bent pipes being conducted from the space above the water in the altar, to the spaces above the wine in the vases; and other tubes being led from beneath the level of the wine in the vases, to the hands of the effigies.

ÆOLIPILE.

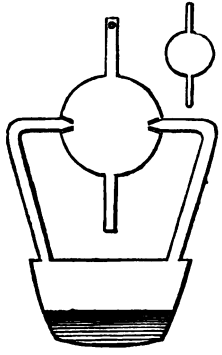


FIG. 1.

The Æolipile is an instrument that has been imitated by Avery in America, and Ruthven of Scotland; and although they are more expensive in steam than ordinary engines, and travel at an

inconvenient speed, yet they are effectual and simple. Hero also invented several other contrivances for the ancient priesthood, who performed many pretended miracles with them. On the revival of learning in Europe, the works of this philosopher became famous, and were translated into various languages, and attracted great attention. The ancients appear to have entertained the erroneous opinion, that water was turned into air by the action of heat; but it is a fact quite certain, that they had a knowledge that both steam and air expanded by heat, for they often used them as motive powers.

(1125.) GERBERT'S ORGAN. In the church of Rheims, there is a clock constructed on mechanical principles, and an hydraulic organ, in which the air, escaping by the force of heated water, fills the cavity of the interior of the instrument, and the brazen pipes emit a modulated sound through the multifarious apertures. There is no evidence whether steam was used, or heated water, in this contrivance, to expand the air. If steam were used, it is the first application of this power on record.

(1543.) GARAY, a Spanish sailor at Barcelona, propelled a vessel of 200 tons burden through the water, without sails or oars, by an apparatus of which a large kettle, filled with boiling water, and paddle wheels, were the moving power. This experiment was performed under the direction of Charles V., and considered successful. But similar to all the earlier attempts to develop the power of steam, it was abandoned through apathy. Garay possessed great mechanical knowledge, and understood the properties of steam.

(1571.) MATHESIUS, a German, describes the mighty effects which could be produced by the volcanic force of a little *imprisoned vapour*. Indeed, to the period when Savery flourished, many scientific men, in their writings, hinted at the power to be derived from "vapour;" and they also spoke confidently, that engines could be forced into motion by this agent.

(1606.) PORTA was an Italian, the inventor of the *camera obscura*, and the writer of a commentary on the "Pneumatica" of Hero, in which he describes a drawing of a steam fountain. It consisted of a tube coming from a boiler, or retort, in which steam is generated, and open at the extremity, passes into a cistern almost full of water, the end of the tube being above the level of the water. The steam from the boiler is thus conducted into the space above the water, and pressing on that element by its elastic power, forces it through a tube. This was the precursor of Worcester's engine; also of Kircher's, and a part of Savery's. The steam is generated in a separate vessel from that containing the water to be raised. Porta speaks of "water rushing into vacuum formed by the condensation of vapour;" from which, in all probability, Watt derived an idea of his condenser.

(1615.) DE CAUS treats of the theory of moving forces, and describes a number of machines: amongst them, one for raising water by fire. He says, "Take a ball of copper, well soldered at every part; it must have a vent hole to put in the water, and also a tube, which is soldered to the top of the ball, the end of which approaches near to the bottom of the ball without touching

it. After filling this ball with water through the vent hole, stop it close, and put it on the fire; when the heat, striking against the ball, will cause all the water to pass through the tube." "The steam formed by vaporation of the water," says Mr. Reid, "having no exit, will accumulate until it has sufficient elastic force to press on the surface of the water so strongly, as to cause part of the water to ascend through the tube; and by continuing the heat thus, all the water may be expelled."

De Caus mentions a scheme of a solar fountain; but is an imitation of Hero. He thus gives the enormous force of steam:—Take a ball of copper, of one or two feet diameter, and one inch thick, which being filled with water by a small hole subsequently stopped by a peg, so that neither the air nor water can escape; it is certain, that if the said ball be placed over a great fire, so that it may become hot, it will cause so violent a compression that the ball will be shattered to pieces." M. Arago ascribes to De Caus a knowledge of "numerical appreciation," beyond that possessed by the ancients; but the force of steam was well known to them, and they ascribed earthquakes to pent-up vapours, generated by subterranean heat. For ages the lime-burners of Italy were obliged to introduce hollow lime stones into their kilns; as the water within them, when converted by heat into steam, caused dangerous explosions.

(1629.) Branca was the first person that proposed to use steam as a moving power, which was accompanied with a specific plan and published. His engine consisted of a wheel, furnished

with buckets round its periphery, after the manner of an over-shot water-wheel, against which a jet of steam, proceeding from a boiler, is made to impinge; thereby forcing the wheel into revolution, and thus causing a rotatory motion. An engine on this plan would be very ineffectual, but inferior to the Æolipile of Hero; for although it is undoubtedly the fact, that the power of steam issuing from the orifice is expended in giving velocity to its own particles, and ought therefore, theoretically speaking, to be again surrendered by those particles during impact, yet this result cannot be realised in practice; and the great velocity at which the wheel requires to travel, makes the scheme perilous and impossible. Pilbrow has revived this species of engine, but without success.

(1663.) The MARQUIS of WORCESTER published a pamphlet entitled, "A Century of Names and Scantlings," with a view to obtain the aid of government for their prosecution. Among these ingenious but impracticable devices, he describes a fire-water engine, which was the first contrivance for raising water by steam power; and it is stated, that it is in this application that the modern steam engine owes its origin. This engine has been applied to a weighty purpose; and from this date this department of science has never retrograded, but has progressed. Some have said that Worcester's engine was only an imitation of De Caus. The instrument of the latter was a puerile one, never intended for practical purposes. In another part of his book, Worcester thus writes of his water work:

"An engine so contrived that, working the

primum mobile forward or backward, upward or downward, circularly or cornerwise, to and fro, straight, upright, or downright, yet the pretended operation continueth and advanceth, none of the motions above-mentioned hindering, much less stopping the other; but, unanimously and with harmony agreeing, they all augment and contribute strength unto the intended work and operation; and, therefore, I call this *a semi-omnipotent engine*, and do intend that a model thereof be buried with me." This versatile *primum mobile* must surely be steam. He also speaks of a water-work, "by many years' experience and labour, so advantageously by me contrived, that a child's force bringeth up, an hundred feet high, an incredible quantity of water, even two feet diameter, so naturally, that the work will not be heard even in the next room; and with so great ease and geometrical symmetry, though it works day and night, from one end of the year to the other, it will not require forty shillings reparation to the whole engine, nor hinder one day's work; and not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as to keep sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions."

The Marquis of Worcester not only succeeded in making a powerful and effective engine, but had arrived at a very just conception of the important ends such a machine may be made to fulfil. None of the contrivances before his time were provided with means to make their action continuous; and the instrument of De Caus, so far

from being adapted to raise water from mines, or for the supply of towns, had merely the power of emptying itself of the boiling water with which it was filled. Indeed, it appears undeniable, that Worcester was the first to construct a water-commanding engine, of power and utility; and he seems to have brought his contrivance to nearly all the perfection of which this species of engine is susceptible. There is no evidence that he made use of atmospheric pressure as an aid to the final effect; but he seemed perfectly conscious of the applicability of that agency, and indeed speaks of it as if such an application was very well understood in his time." This engine "is represented as provided with one boiler, for there could not have been in this kind of machine any feeding pump; and in the absence of that instrument, two boilers must have been indispensable to make the action of the engine continuous." Besides, the description says, "that one vessel of water consumed, another begins to force and refill with cold water;" which we take to mean, that, when the water of one boiler is evaporated, it is filled up with cold water, and the other is, in the meantime, put into operation; the water in the boiler last filled having again become hot, before that in the other is exhausted. One of these engines appears to have been set up to draw water out of the Thames, at Vauxhall, in 1653.

The principle of atmospheric pressure was employed in this engine; for it is difficult to perceive by what power, other than suction, the necessary rapidity of motion could be given to the water in the pipe, leading from the river to the engine, and which would appear to be smaller than the pipes applied in other cases.

(1682.) In the Harleian Miscellany is preserved, that Sir Samuel Morland constructed a contrivance for raising water, called "The principles of the power of fire, invented by Chevalier Morland." This work was exhibited to Louis XIV., the author states, "Water being evaporated by the force of fire, these vapours shortly acquire a greater space (about 2000 times) than the water occupied before; and were it to be closely confined, would burst a piece of cannon. But, being regulated according to the rules of statics, and reduced by science, by measure, weight, and balance, then they carry their burden peaceably, like good horses; and thus they become of great use to mankind, particularly for raising water."

(1690.) PAPIN was a Frenchman; and amongst those who preceded James Watt, no one can more fairly claim greater merit than this ingenious mechanical professor. He was the first to show that a piston working tight in a cylinder, might be raised, by boiling water under it; and that when raised, by cooling and condensing the vapour which had raised it, a vacuum would be formed below it, when the atmospheric pressure would force it down. In his *Acta Eruditorum* he thus describes his engine: "Water has the property, when changed into vapour, to spring like the air, and afterwards to recondense itself so well by cold, that there remains no appearance of this force of springing." In the London Philosophical Transactions for 1697, this engine is thus noticed: "A method for draining mines where you have not the conveniency of a near river to play the aforesaid engine (one with air pumps and cylinders, connected by an air pipe); where, having touched

upon the inconvenieney of making a vacuum in the cylinder for that purpose with gunpowder, according to his first scheme of 1687, he proposes the alternately turning a small surface of water into vapour by fire applied to the bottom of the cylinder which contains it, which vapour forces up the plug (piston) in the cylinder to a considerable height; and which (as the vapour condenses as the water cools, when the fire is taken away) descends again by the air's pressure, and is applied to raise the water out of the mine." Thus, if Papin's inventions were unsuccessful, yet he did much in preparing the way for others.

Papin was also the inventor of the Safety-valve, and of the Digester, now in use. In this digester, by confining the steam, a greater heat is procured than can be had from water allowed to boil in an open vessel; and which, as he says, "extracted marrowy nourishing juices from bones and beef, even the oldest and hardest cow-beef, and other meats, whose horny and shrivelled fibres baffled the skill of the most experienced cooks to prepare for mastication with common boilers; when done in this digester come forth succulent and pulpy."

(1698.) SAVERY proposed to raise water by the force of steam applied directly to water, which was abandoned. In the engine invented by this officer, a vacuum is introduced with much effect; and instead of the water in his engine being forced up all the way by steam pressure, the receiver, or forcing vessels, are situated thirty feet above the level of the water, to which height the water is drawn by the vacuum created within them.

All our ancient philosophers deemed a vacuum impossible and unnatural. Galileo was the first

to question this. On an application of a pump to a very deep well, sunk by the Grand Duke of Tuscany, at Florence, it was found that the water would rise more than thirty-two feet, leaving the upper part of the pipe empty; from which Galileo inferred, that a vacuum did not extend beyond thirty-two feet of water. Torricelli, a pupil of Galileo, discovered, in 1643, that the effort of any fluid open to the atmosphere to enter a vacuous space, is owing to the pressure of the air upon the bodies on the earth's surface. This discovery gave great impulse to mechanical ingenuity; and many schemes were contrived to make this new agent available as a motive power. The first of these projects that appears to have been of any use, was the fire-engine of Savery, who produced a vacuum by condensing steam in close vessels, and then applied the vacuum so obtained to the elevation of the water. He also made use of the elastic force of steam, after the manner proposed by Worcester; but he made the pressure of the atmosphere carry up the water the first stage, which the marquis does not appear to have done; although there must have been a vacuum created in his receiver as effectually as in that of Savery, occasioned by the condensation of the steam on the entrance of the cold water. Savery's patent bears date 1698. He also published a work called the "Miner's Friend, or an Engine to Raise Water by Fire;" this was printed in 1702. Mr. Reid remarks, "There is little of interest in the boiler used for this engine. The gauge pipes, for ascertaining the quantity of water in the boiler, were the invention of Savery; and

he applied to his boiler the safety-valve, which was invented by Papin for his digester."

It has been gravely discussed, whether Savery invented the engine himself, or borrowed the idea of Worcester. Desaguliers relates a story about Savery having purchased up the whole of the impression of Worcester's book; but this has been contradicted. It is quite certain, however, that it was the ingenious Savery who first introduced the fire engine into extended use, and he prosecuted his scheme with great success.

(1705.) NEWCOMEN and CAWLEY. Newcomen's engine, as first constructed, was provided with casing around the cylinder for holding cold water, to accelerate the condensation of the steam; and the surface of the piston was covered with water, to prevent the passage of air past it. The steam was admitted from the boiler by a slide valve, or regulator, as in Savery's engine, which was moved by hand; and after the cylinder was filled with steam, water was introduced into the external casing, by which, in the process of time, the steam was condensed, and the piston made a stroke. The engine was very untractable, until the method of condensing the steam by a jet of cold water was introduced, and the movement of the valves was effected by the engine. These improvements were the effect of accident.

Newcomen and Cawley were the first who arranged the moving power of the engine in such a way that the steam did not act directly on the water to be raised, as in Savery's, or in Papin's second engine. The water was raised by means of a common suction pump, worked by the engine, instead of by horses, as formerly. The engine

consisted of a boiler, a separate vessel, in which the steam was generated, a cylinder in which it was condensed, and the beam, whose movements followed the alternate admission and condensation of the steam, and which communicated the motion to the rod of the pump. This engine was in use, as improved by Smeaton, for nearly a century, until superseded by the magnificent engines by Watt.

(1718.) DESAGULIERS. The ingenious devices and mechanical arrangements, resorted to by Torricelli and Otta Guëriche, were followed by Papin and Savery; and the only material difference between the cylinder apparatus and the atmospheric steam engine is that, in one case, the vacuum is produced by means of a pump, and in the other by the condensation of steam. It is in the production of a vacuum, therefore, by the agency of steam, that any merit in the contrivance of the atmospheric steam engine must be held to consist; for the efficacy of a vacuum, when produced, in raising heavy weights, or the production of other powerful mechanical effects, could not fail, after Guëriche's experiments, to be obvious to every one. Savery says he "discovered the efficacy of steam in the production of a vacuum, by plunging the neck of a flask he had accidentally thrown upon a fire, with a little wine in it, into a basin of water, when the steam raised from the wine was condensed, and the water rose in the flask and filled;" but Desaguliers throws a doubt on this account, by saying, that in such an experiment, the flask would have been forced from the hand of the operator by the impulse of the entrant water, a circumstance of which Savery makes no mention. Desaguliers is chiefly known

to the scientific world in consequence of his alterations in Savery's engine. He was an author of some celebrity, and wrote a work on Experimental Philosophy, published 1743. He employed only one receiver, and condensed the steam by throwing a shower of water into the receiver, instead of upon its external surface. He thought by employing only one receiver, and confining the steam in a boiler while the receiver was being filled by the atmospheric pressure, the steam would acquire such a strength, that upon being turned into the receiver now filled with water, it would press up a considerable portion of the water, even before the upper surface had become much heated; and thus there would be less loss of steam than in the original plan where the steam acted without intermission, being thrown into one receiver immediately after it had pressed the water out of another.

(1772.) LEUPOLD contrived a very elegant high-pressure engine, distinguished by refined ingenuity. It was identical with that of the double-acting engine. The employment of high-pressure steam, however, could not but be considered as very objectionable, at a period when the boilers were so unsubstantially constructed; and in all probably it was in consequence of the rude manner of their construction, that high pressure did not then succeed. The domes of the boilers of Newcomen were generally of lead, the inferior portions being composed of copper. It was left to other times, and to other men, to construct boilers of iron plates rivetted together, so that high pressure steam might be placed upon them with impunity. From the improvement in valve-gearing by Beighton (1718), very little appears to have been

effected until the time of Smeaton. Brindley added a contrivance of a float in the boiler, to regulate the admission of the feed water; and he also proposed that a boiler should be constructed of wood or stone, furnished with an internal furnace, and internal flues.

Smeaton constructed an engine for the New River Company, in which he introduced some alteration. Conceiving that much power was lost in the rapid reciprocation of the beam, and in giving needless momentum to the water in the pumps, he determined to work the engine at less velocity, to employ larger pumps, and to load the piston with ten pounds and a half upon the square inch, instead of seven pounds, which had been the usual practice. The main centre was removed from the middle of the beam to a point nearer the end, from which the pumps were hung; and the cylinder was made tall, and of small diameter, by which he imagined that the steam would be more readily condensed, and a less amount of injection water be required.

Smeaton also constructed another engine for Long Beaton colliery, which, in all its main features, was similar to the contrivance of Beighton, but distinguished by juster proportions, and a greater attention to detail. The alterations thus introduced were found highly beneficial. This engine Smeaton considered his best performance; but his chase-water engine, erected in 1755, in a mine in Cornwall, far surpassed all his other conceptions. He also introduced effective boilers; his favourite was the "Haystack Boiler," formed of cast iron, ten feet in diameter, and sixteen feet four inches high, and constructed to supply a-

engine with sixty-six inch cylinder, and eight feet and a half stroke. This variety was constructed for the purpose of pumping out water from the docks at Cronstadt, in Russia. The atmospheric engine is still in use, where coals are cheap.

CHAPTER II.

WATT'S LIFE, CHARACTER, AND ENGINES.— 1736-1800.

JAMES WATT was born at Greenock, in 1736. He was brought up as a mathematical instrument maker, he came to London in 1754, but returned to Glasgow in 1758, and commenced business on his own account. The professors of the university of Glasgow appointed him philosophical instrument maker to the college, and gave him apartments in the building. His attention was first directed to the steam engine by Dr. Robison, who suggested the idea of applying the power of steam to the moving of wheels of carriages. In 1761 and 1762, he instituted some experiments on the force of steam in Papin's digester. With this instrument and a syringe, with a solid piston, he formed a species of steam engine similar to Leupold's, which failed.

In 1763-4, the university sent him a model of Newcomen's engine to put in working order. The cylinder of this model was two inches in diameter, the length of the stroke six inches, and the boiler considerably larger in proportion, than the boilers of practical engines. Watt discovered that the boiler did not supply the engine with steam enough; and in order to enable the engine to work, he reduced the load on the piston by lowering the column of water. He found that the waste arose from the alternate heating and

cooling of the cylinder. In 1765, the idea presented itself to him of preserving the cylinder at an uniform high temperature, and condensing the steam by opening a communication between the cylinder and a separate vessel always kept cool, which he called a *condenser*. In 1769, Watt took out a patent for his improvements; and about this period he joined Dr. Roebuck, and abandoned his former business.

NEWCOMEN'S ENGINE.

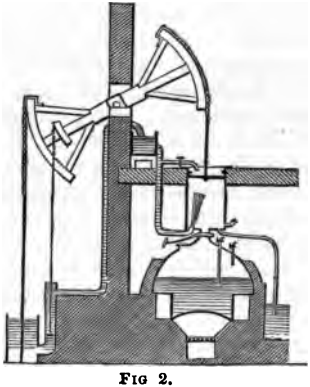


FIG 2.

Dr. Roebuck rented some large coal-works at Kinneal, and the first of Watt's engines was erected there. It had a cylinder of eighteen inches diameter; and was altered and modified in various ways, until it reached considerable perfection. In 1773, Dr. Roebuck transferred his interest in Watt's projects, to Mr. Boulton. In 1775, he obtained an extension of his patent

for twenty-five years. He then settled at Birmingham, and constructed, by the aid and capital of Boulton, and brought into use, engines by which immense savings in fuel were effected. In 1778, many of his engines were at work, and quickly superseded the old ones. In this year, he introduced the expansion steam engine; and in 1782, he took out a patent for the last great change he effected on the engine, giving it the *double-acting* power. Many other improvements were introduced, from time to time, but this was his grandest, as it adapted the engine for the important purpose of impelling machinery. In 1800, Watt retired from business.

Those who consider Watt only as a great practical mechanic form a very erroneous idea of his character: he was equally distinguished as a natural philosopher and a chemist, and his inventions demonstrate a profound knowledge of those sciences, and that peculiar characteristic of genius, the union of them for practical application. The steam engine before his time was an imperfect machine, the result of simple experiments on the compression of the atmosphere, and the condensation of steam. Watt had to investigate the cause of the cold produced by evaporation of heat occasioned by the condensation of steam—to determine the source of the air appearing when water was acted upon by an exhausting power; the ratio of the volume of steam to its generating water, and the law by which the elasticity of steam increased with the temperature: labour, time, numerous and difficult experiments were required for the ultimate result; and when his principle was obtained, the application of it to

produce the movement of machinery demanded a new species of intellectual and experimental labour. He converted rectilinear into rotatory motion, and invented parallel motion, and by regulating centrifugal force of the governor, he placed the machinery entirely under the control of the engineer. Eighty years only have passed since these great discoveries of Watt. Sixty years have elapsed since it has been reduced to practice on an extensive scale.

It has been calculated by an ingenious man (M. Dupin), that the power of steam engines managed by thirty-six thousand men, would have been sufficient in eighteen hours to raise the great pyramid of Egypt, which required the labours of one hundred thousand men for twenty years.

Watt subdued and regulated the most terrific power in the universe—a power which, by the joint operation of pressure and heat, probably produces tremendous convulsions of the earth; this he brought into a state of such perfect organization and discipline, that it may now be safely manœuvred and brought into irresistible action—irresistible, but still regulated, measured, and ascertained—or controlled at the will of a child. Thus one man directs it into the bowels of the earth, to tear asunder its very elements, and bring to the light of heaven its concealed treasures, another places it on the surface of the wild waste of waters to battle with the winds of heaven, to oppose the tides and currents, and as if to defy the waves of seas and oceans.

Our mines are drained, their products raised, machinery of every description, which formerly required an immense amount of human labour, is

now performed by the power of steam, and a force equal to that of 500 men, can be, with the greatest ease, controlled by sawing stones and wood, and raising water, are effected by the same means, which produce the most minute, ornamental, and elegant forms. The anchor is forged, the die struck, the metal polished, the toy modelled, and the same giant arms twist the cable, the protector of the largest ship of the line, and spin the gossamer-like threads to ornament feminine loveliness. The elements have to a certain extent been subdued and made subservient to the uses of man, and, by a kind of philosophical magic, the ship moves rapidly on the calm rivers, oceans and seas, and makes way against the most powerful stream, and reaches her destination, though opposed by tide and storm.

We can never doubt that by our wealth, by our capital, by the means which Providence has afforded us in being the country which has of the whole world the greatest command of fuel, we must always have advantages in the employment of the steam engine, which can belong to no other nation in an equal degree with ourselves.

There was one quality in Watt which most honourably distinguished him from too many inventors, and was worthy of imitation. He was not only entirely free from jealousy, but he exercised a careful and scrupulous self-denial, and was anxious not to appear, even by accident, as appropriating to himself that which he thought belonged even in part to others. He refused the honour universally ascribed to him, of being the inventor of the steam engine, considering himself simply its improver. Thus, wherever an original

mind produces new combinations of thought and feeling, whether its means be words or colours, or marble or sound, or command over the mighty agents of Nature; whether the result be an epic poem, a statue, or a steam engine, we must equally reverence and admire those transcendant faculties which we denominate "Genius."

The engine of Watt, next to Newcomen, in the progress of invention, known as the modern steam engine, has been but very little altered since it came fresh from his hands. It occurred to him, while examining Newcomen's model at Glasgow, that if a communication were opened between a cylinder containing steam, and another vessel which was exhausted of air and other fluids, the steam as an expansive fluid would rush into the empty vessel, and continue to do so until it had established an equilibrium; and, if that vessel were kept very cool, by an injector or otherwise, more steam would continue to enter, until the whole was condensed. Thus by detaching the apparatus for condensation; by having, separate from the cylinder, a vessel in which the steam was to be condensed, he accomplished two objects—first preserving the cylinder at an uniform high temperature; and secondly, of having a perfect vacuum within the cylinder, so that little or no resistance was offered to the descent of the piston. By preserving the cylinder constantly at the necessary temperature, no steam was wasted in raising its temperature, as in the atmospheric engine; and thus was solved the great problem in the steam engine—*forming a vacuum without cooling the cylinder;* thereby saving all the steam which

was formerly used in heating the cylinder, from the condensing point up to the boiling point, after each condensation.

The annexed engraving is the condenser and apparatus. It communicates with the cylinder by a pipe at its lower part, and with the air-pump by a valve between them. This valve is so constructed as to permit the passage of fluids from the condenser to the air-pump, but not from the air-pump to the condenser. The condenser and air-pump are surrounded with cold water, a jet of which is constantly injected into the condenser. The piston of the air-pump is alternately raised and depressed by the beam of the engine, to which its rod is attached, and thus the fluids are drawn out of the condenser. At the right of the air-pump is the hot well, into which the piston

CONDENSER.

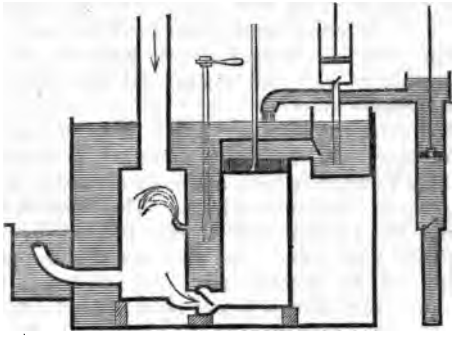


FIG. 3.

of the air-pump throws the liquids which it draws from the condenser. To the extreme right of the

figure is the pump worked by the engine, which produces water to surround and supply the condenser.

At the left of the engraving is a tube leading from the condenser, with a plug permitting the exit of any fluids, but not the entrance of any: this is denominated the "snifting valve."

When the engineer receives the order to proceed, he opens all the valves to drive steam through the engine to expel the air. This current is forced through the snifting valve. The injection cock is then adjusted so as to pour in the necessary quantity of water into the condenser. The snifting valve has been for some time dispensed with, although, at a former period, it was considered of great utility.

The steam after performing its duty on the piston proceeds to the condenser, where it is instantly transformed into water. By this operation the condenser would soon be filled with injection water, condensed steam, and air, which enters along with the steam, did not the air-pump remove them.

The valves of the air pump open upwards; when, therefore, the piston is raised, as nothing can pass through it from above downwards, there is a vacuum below the piston. The valve at the bottom of the condenser being pressed by the fluids in this vessel, opening towards the air-pump, and that pressure not being resisted in the air-pump, the valve is forced open, and the fluids rush from the condenser to the air-pump. When the piston of the air-pump descends, it tends to press the fluids back into the condenser; but, from the construction of the valve, they cannot

return. Being thus pressed by the descending piston, they force open its valves, and pass through it to the upper side of the piston, where they accumulate. When the piston ascends again, they are lifted by it, and transferred to the hot-well. By this series of actions, regularly continued while the engine is at work, the fluids in the condenser are withdrawn from it, and thrown out into the hot-well. The water removed from the condenser being warm (having received much of the heat of the condensed steam), is not altogether thrown away; but part is returned to the boiler, being conveyed, by a pump dipping into the hot-well, to the cistern at the top of the feed-pipe. Thus a part of the heat which the steam carried from the boiler is returned to it. This pump is worked by a rod from the beam of the engine. The cold water is supplied, and the whole apparatus kept cool, by water pumped by the engine, also worked by a rod from its beam.

The condenser communicates freely with the lower part of the cylinder by a tube of considerable diameter. It is kept constantly cold by being immersed in a well or cistern of cold water, which is withdrawn as it becomes heated, and fresh water supplied; and the rapid and constant condensation of the steam is insured by a jet of cold water, which continually plays into the interior of the condenser. By these means, the temperature in the interior of the condenser is kept at about 100° Fahrenheit; the vapour then having a force of only about 0·97 lbs.—less than 1 lb. to the square inch. And, in that part of the cylinder which communicates with the condenser the elasticity of the vapour will be equally low.

The injection water, the water formed by the condensed steam, and the air which enters along with the steam, would soon accumulate, and fill up the condenser. This is prevented by establishing a communication between the lower part of the condenser and an air-pump, worked by the engine itself, which withdraws the water and air that would otherwise accumulate, and preserves the condenser always in working condition.

In Newcomen's engine, a cooling effect was produced by the cold air following the piston in its descent. It was necessary that this should be avoided, if the cylinder were to be preserved at an uniform high temperature. Accordingly, the cylinder was closed at the top, the piston-rod moving through an air-tight and steam-tight aperture.

The air being thus entirely excluded, the descent of the piston was effected by the introduction of steam above it; and the elastic force of steam from the boiler was substituted for the atmospheric pressure in pressing down the piston. Thus the engine became really a steam engine. Steam was employed to form the vacuum, and steam was also employed to give the force or moving power.

In the atmospheric engine, the cylinder was considerably reduced in temperature by the action of the surrounding air. To prevent loss of heat from this cause, Watt enclosed the working cylinder in another (called a jacket) of wood, or some substance which gave heat a slow passage through it, and thus tended to confine the heat in the cylinder.

From the employment of steam to press the piston down, this advantage also was gained—the engine was not limited to one degree of force—that of the atmospheric pressure; but its power might be increased or diminished, according to the force of the steam used to effect the motion, which, within certain limits, could be varied considerably.

In Newcomen's engine, the piston was kept air-tight by water poured over its surface. This was inapplicable in Watt's method, where the piston was moved by the force of steam, and the cylinder was closed above, as, if any water entered the

WATT'S DOUBLE-ACTING ENGINE.

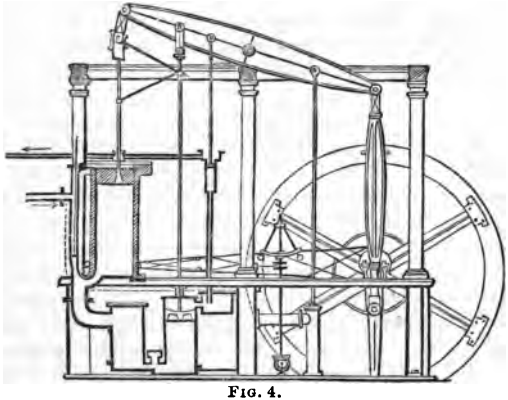


FIG. 4.

hot cylinder, it would be formed into vapour, which would retard the production of a vacuum, and cool the cylinder. He, accordingly, preserved the piston air-tight by melted tallow, wax, and oil.

In Newcomen's engine, there was only a downward motion of the piston available as a force: the piston was pulled upwards by the clumsy expedient of a weight attached to the end of the beam, and gave no impulse in ascending. In Watt's double-acting engine the steam entered alternately above and below the piston; at the same time forming a vacuum alternately above and below it, and thus a moving force was communicated to the piston in ascending as well as descending, and a continuous moving power created. The machinery converted the up and down motion of the piston into a continued *circular* motion, and insured steadiness and regularity in the engine so as to adapt it for impelling machinery. Watt introduced many other improvements, in order to render his engines effective, and thus giving them almost self-acting powers.

THE BOILER.

The Boiler is the vessel in which steam is made, and it is an important part of the steam-engine. The adjustments of the boiler and cylinder to each other is very beautiful, by which the engine regulates the supply of steam to the cylinder, of water to the boiler, and of heat to the furnace. It thus, in a manner, itself proportions the supply to the demand, with regularity and precision. The boiler here described is for a land engine, acting on the principle of condensation or low-pressure, or condensing engines. The boilers of marine condensing engines are similar in construction, but their varieties are greater. Hundreds have been constructed since, of all manner of shapes and dimensions, some filled with tubes,

which are called tubular boilers; others are denominated multitubular boilers, which are crammed with a greater number; and others with vertical tubes, in order that they may generate more steam; but in most instances these tubes have prevented the engines from working with efficacy. At the same time, a moderate number of these tubes will enable the boiler to make more steam than one without them.

The boiler is now constructed with sheet-iron plates riveted together. It has two principal tubes; one conveys to the interior, water to be made into steam, the other conveys steam from the boiler to the cylinder. It has gauge cocks to ascertain the height of water in it; a steam gauge to indicate the elastic force of the steam; a safety valve to permit the egress of steam; and an internal valve to admit air and prevent the boiler being collapsed by atmospheric pressure. If the elastic force of the steam in the interior be suddenly diminished, this occurrence is likely to take place.

It has also a man-hole to permit the boiler to be cleaned. It is placed on a furnace supplied with a self-acting damper, which may be made to feed itself with the fuel necessary. Brunton and Stanley's furnace is considered the best; but this was first described by Steel of Dartmouth, and patented by Brunton. It is, therefore, doubtful to whom this invention can be ascribed.

Boiler Incrustations.—A new and simple mechanical method of preventing boiler incrustations has been recently invented. It consists in placing a series of pans of sheet iron throughout the length of the boiler, which receive the various

deposits from the water, and may easily be removed and cleaned once a month. These pans are thirty inches long, seven wide, three deep, and stand on feet an inch and a half high. Pans placed in this position receive and retain the deposits, the fire and ebullition not possessing sufficient power to remove them, whilst these agencies, acting on the bottom of the boiler, prevent any accumulation there, which, as is well known, do not form compactly, unless in considerable quantity. This remedy possesses the advantage of not requiring any supervision.

SAFETY VALVE.

The object of this valve is to permit the escape of steam, should it possess more force than the boiler can support; thus preventing an explosion of the boiler. It is loaded, and will open with a pressure of steam, a little more than is necessary to work the engine, and much less than the utmost the boiler can bear.

The steel-yard safety valve consists of a lever, the point or fulcrum of which is set on a support at the side of a short tube or pipe, communicating with the boiler. From the lever over the aperture of the tube, a rod descends, having a plug attached, which closes the tube. At the other extremity of the lever, weights may be attached at different distances from the fulcrum, which will possess the power of keeping down the valve or plug, in proportion to their distance from the fulcrum. The force of the steam will tend to push up the plug or valve, and permit the escape of the steam. The atmospheric pressure, and the weight attached to the lever, will

tend to press down the plug, and prevent the exit of steam. The valve will open and shut according to the relative strength of these forces, acting on it in opposite directions. Sometimes the valve becomes impaired, and accidents may occur by the sudden formation of steam which cannot escape with sufficient rapidity when the water is shallow in the boiler, or the decomposition of the steam, or water, by the heated sides of the boiler. This valve opens outward to the air.

THE INTERNAL SAFETY VALVE

opens inward: its use is to admit air should the steam be condensed suddenly. Were there no such valve, the atmospheric pressure on the surface of the boiler would crush it, or cause it to collapse, if any sudden diminution of the force of the steam should take place. This internal valve yields, and admits the air, when the internal pressure is greatly diminished, and thus produces an equilibrium. The furnace, above which the boiler is placed, is entirely excluded from air, excepting at two parts, at the grating, on which rests the fuel, and between which the air enters and induces combustion, and at the throat at the bottom of the chimney, where the smoke, and products of combustion, leave the furnace. Thus no cold air is admitted to the chimney, and the draught is rendered more powerful, air supplyed more quickly to the fuel, and the heat produced more intense.

There are a great many contrivances to prevent smoke. Watt, and a host of others, have taken out patents for this purpose. Papin was the first who attempted to prevent it. The usual

method is, by constructing the furnace so that the new coal is introduced below the live coal, by which the smoke, arising from the fresh fuel, is consumed as it rises. This is Witty's invention. Sometimes, to retain heat, the furnace is placed inside the boiler, and the flue also conducted through the same: this is thought the best contrivance.

ECCENTRIC ROD.

The object of this rod is to work the valve, to communicate an alternate rectilinear motion to the rod, so that the valve may be made to assume alternate positions. The axis on which the fly-wheel turns, possesses a continued circular motion. By means of the eccentric rod, and one or two bent levers interposed between the axis and the rest of the side valve, the latter is moved.

CONDENSER GAUGE

shows the elastic force of any vapour that may remain in the condenser, in order to ascertain the completeness of the vacuum in it. As water retains the state of vapour at a very low temperature in the condenser, however cool, some will exist, and its elastic force may be ascertained by communication with a bent tube, containing mercury, open to the air at one end, and to the condenser at the other.

THE GOVERNOR.

The object of the governor is to determine the quantity of steam that shall enter the cylinder, and thereby regulate the action of the engine, should it happen to work too vigorously, either from the increased activity of the fire or diminished

resistance; or to work languidly from the opposite causes. The throttle valve, in the steam pipe, regulates the quantity of steam which passes through, by the degree in which it lies parallel to or across the tube; and it is by the governor that the direction of this valve is determined.

This regulator, or governor, was used by millers to regulate the rate of motion of the grindstones. In steam-boat engines, the levers of the throttle valve are under the immediate control of the engine-man, who acts as the governor.

THE BEAM.

In all of Watt's engines, the beam was used. In those to be applied to move machinery, the crank and fly-wheel were adopted by him, and always used. The piston-rod is the instrument by which the motion is transmitted from the cylinder. But, for the double-acting steam engine, where the piston has to communicate motion both ways, *to push up* as well as to *pull down* the beam, the connexion of the ends of the beam and piston, by a flexible chain, would not answer, as the chain could not communicate an impulse. It was, therefore, necessary that the piston should be connected immediately to the end of the beam, or that some rigid inflexible bar should be interposed. For this purpose, a parallel motion was effected by Watt, in the manner which will be understood from the following figure.

PARALLEL MOTION.

Let R be the head of the piston-rod P R; B the end of the beam. B describes a segment of

a circle, and R moves vertically up and down. These motions are adjusted so as to harmonise with each other by the following contrivance :—

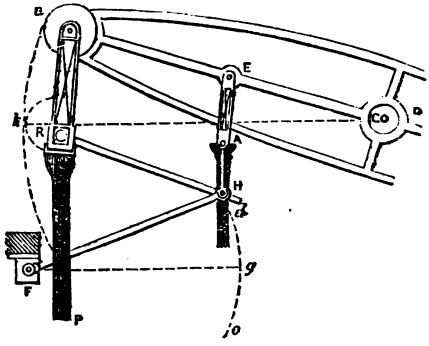


FIG 5.

Let a fixed point (F) be taken, as near as possible, to the line in which the piston-rod moves. From the points B and E of the beam, let inflexible bars B R and E H hang down, moving freely on pivots at B and E. Let the extremities, H and R, of these bars be connected by a transverse rod, R H; and let another rod pass from H to F—all having free motion on pivots at both extremities. Let the head of the piston-rod be attached to the pivot at R—then it will have vertical motion without any considerable strain, from the *outward* motion of the beam during the first half of its *descent* and the first half of its *ascent*, or from its *inward* motion during the latter half of its *descent* and the latter half of its *ascent*; for

while, in the descent of the beam to the horizontal position from that shown in the figure, the bar (B R) is pushed outwards by the beam, as will be seen from the inclination of the bar, and from considering the motion of the point B, moving on the centre (C) the rod, R H, counteracts this, by pulling the point (R) in an opposite direction, the end (H) of the rod (R H) being preserved at a proper distance from the required line of motion of the piston rod, by the rod H F, which, fixed at F, describes with its extremity (H) the arc *(d g)*, which bends inwards as much as the arc, described by B, bends outwards, and thus preserves the point (R) moving vertically. When the beam has come to the horizontal position (shown by the dotted line C *k*), the bar (B R) will then hang perpendicularly, and the rod (F H) will also be horizontal, as in the dotted line, F *g*. In the latter part of its descent, the point (B) will evidently bend *inward*, and tend to push inward the head (R) of the piston-rod; but the rod (F H) then bends *outward* (describing the arc, *g o*); and thus (by the rod, R H) resists the inward thrust of the beam.

In ascending, similar adjustments take place between the beam and the piston-rod, and the latter is preserved always vertical, or nearly so, and all strain in one direction neutralised by the opposite action of the rod, R H.

The parallel motion is now frequently dispensed with, by causing the head of the piston-rod to move in a groove or slide, or by connecting it with cranks, as in the beautiful and effective engines of Messrs. Penn and Son.

THE CRANK,

the object of which is to procure from the reciprocating motion of the end of the beam, that motion which is required for all sorts of machinery, for propelling steam-boats and steam-carriages—a continued circular motion. The crank and fly-wheel had long been used in the spinning-wheel and turning lathe—for procuring a circular motion from the rectilinear motion of the foot, in its pressure on the treadle.

DEAD POINTS.

There are two points in the revolution of the crank, called *dead points*, where the engine has no action upon the crank in turning it, but pulls or presses it vertically, the crank being in such a position, that it has no tendency to turn the axis.

The crank is carried easily by its inertia out of the critical situations, but it exerts little or no force in turning the axis while in them. The crank moves slowly when about the critical points —more rapidly in the other situations, where the beam acts directly in turning it. Hence, an inequality in the motion of the axis, and any machinery which derives its motion from it. This is remedied by the

FLY-WHEEL.

In applying steam to drive machinery, it is very necessary that the engine should work with a perfectly steady and uniform force; that there should be no irregularities in its action; or, if unavoidable, that these should be transmitted very gradually to the machinery; that there

should be no abrupt transition from slow to quick, or the reverse. These might arise from the diminution in the imputus of the crank at the two critical points from changes to a certain extent unavoidable, in the strength of the fire, or from a change in the resistance given by the machinery, from some of the work being stopped, or more work thrown on. By means of the governor, and throttle valve, the adjustments of the feed pipe, and the damper, a proportion is preserved between supply of steam, and the demands of the engine. But these require some time to come to an adjustment, and before they could be effected, in case of any sudden change, considerable injury might be done. This is prevented by the action of the *fly-wheel*, possessing a heavy rim formed of iron, and fixed to the axis which the crank turns, and revolving along with it. By its weight it acts as a drag on the engine, should it have a tendency to go too fast, and by the impetus which its weight gives to it, carries on the machinery with the usual, or gradually decreasing force, when the proportion of the resistance to the power becomes augmented, and the engine has a tendency to move slow. It equalizes by its weight any irregularities on either side, and distributes gradually, when the power is too great, and restores and gives it out when it is diminished, or the resistance increased.

Watt remedied a cause of inequality in the rate of motion. The piston moved more rapidly with an accelerated motion towards the end of each stroke, than at the commencement, in consequence of the accumulation of its motive inertia, while the steam continued to act upon it

with the same force as at first. At the beginning of the stroke, the steam has to overcome the friction between the piston and the cylinder, as well as the inertia of the mass. When it is once set in motion, its inertia continues it in that state for a time, independently of the action of steam, friction only being now overcome. Hence, if the steam continue to act forcibly as at first, it will communicate additional motion to the piston, and perform its stroke with an accelerated velocity. Watt cut off the supply of steam after the piston had descended a certain length. He states, that when only one-fourth of the descent of the steam necessary to fill the whole cylinder, is employed, the effect produced is more than one-half of the effect which would have been produced in filling the whole cylinder full of steam, by admitting it to enter freely above the piston during the whole of its descent. If a certain quantity of steam produced an effect equal to four, the effect of one-fourth of that steam acting expansively would be more than two.

The following tables will exhibit the gain by cutting of the steam. The first table is taken from the "Steam Engine," the second from Mr. Reid.

If steam be stopped at	Its performance is multiplied
One-half	1·7 times
One-third	2·1
One-fourth	2·4
One-fifth	2·6
One-sixth	2·8
One-seventh	3·0
One-eighth	3·2

The table published by Mr. Reid is somewhat different.

If steam be stopped at	The effect of the admitted is multiplied
One-half	1·69 times
One-third	2·10
One-fourth	2·39
One-eighth	3·08

We leave the writers to reconcile the discrepancies here manifested. The fact of Watt's discovery being beneficial to the working of his spendid engines is all we wish to record, and not the nice calculations of those who affect to improve on the inventions of one of the greatest men of modern times—one who will live in our memories, as long as science shall continue to astonish as well as bless mankind.

CHAPTER III.

MARINE ENGINES.

THE governments of the civilised world are vying with each other in their race after excellence; and war ships and packet vessels, of enormous tonnage, are now floating on the waters of nearly every ocean and sea that surrounds the nations of the earth. Railroads, too, are intersecting every kingdom of Europe and America. India is not behind in the emulation; and in a few years the power of the atmosphere, aided by steam, will carry Englishmen from their shores to the confines of that distant land.

The echo of the cheering hiss of the old tea-kettle, as the boy Watt sat dreamingly listening to it, is to be heard in the loud roar of the steam pipe, rising often above the din of wind and waters, and proclaiming to both that a mighty power is battling with their fierceness. Steam has made this old world of ours a new one; it binds cities together literally with iron bands; it brings kingdoms into as close a contiguity as parishes. What does it not do for man?—services the most mighty and the most trivial. It hurries him across the Atlantic in ten days, and grinds coffee in grocers' shops; it has power to pump up volumes of water from the bowels of the earth, and delicacy enough to drive a shuttle to weave fine linen. Mighty as is its strength, a child may guide it: up and down flies the huge beams and

pistons with a force that hundreds of horses would in vain crack sinew and muscle to control, and yet, let there be but the touch of a guiding lever, the stopping of a valve, demanding no more than a child's strength, and this vast moving fabric at once becomes motionless and passive—only so many tons of wrought and hammered metal.

The first steam-boat that floated on the broad waters, was constructed by *Blasco de Garay*, in the sixteenth century, and was a vessel of two hundred tons burthen. Savery appeared to think this scheme feasible, for he adapted his engine for the purposes of navigation; but proceeded no further than suggesting the idea of a paddle-wheel, attached to a vessel, which might be turned, and thereby impart motion, by water to be raised by an engine. The next project was designed by Hulls, who obtained a patent for it in 1736. This power was gained by a pressure of the atmosphere; and by machinery, he transmitted motion to a paddle-wheel, and provided for the rotation of the wheel during the ascent of the piston.

A steam-boat was constructed in France, in 1755, by M. Perier. It was launched on the Seine, but was given up by the projector. A much larger vessel was built at Lyons, by the Marquis Jouffray, in 1782, to be propelled by steam, but his intentions were frustrated by the demon of political contention. This boat was one hundred and forty feet long, fifteen wide, and was laving the bosom of the Seine for some time. Symington, in 1788, constructed an engine for propelling a boat, under the direction of Miller of Dalswinton, which plied on the Forth of Clyde Canal with success, in 1789; but as the agitation

of the water was thought injurious to the banks, the boat was abandoned. Lord Stanhope constructed, in 1795, a machine for propelling vessels on the Thames, which was unsuccessful. Lord Dundas, in 1801, induced Symington to construct a steam-boat for towing vessels on the Forth of Clyde Canal; but this, like the previous scheme, was abandoned.

It was reserved for the people of the western world to boast, that one of their countrymen first launched an efficient vessel. This boat was afloat in New York, in 1807. It was constructed under the direction of Fulton, an American, who had for some years been endeavouring to introduce steam navigation. The engines were built expressly for him, by Boulton and Watt. The first voyage was performed between New York and Albany (110 miles), in thirty hours, which induced all civilised nations to imitate his example. A few days after this trip, Stevens, another American, also effected a successful steam-boat voyage. But although the honor is due to Fulton, yet without the genius of Watt and the skill of his firm, he could not have succeeded, the boat then was Fulton's, but the power afforded to propel the vessel was Watt's; Fulton deserves honourable notice for his energy and perseverance, but Watt's genius and practice alone gave Fulton his celebrity. All credit to both say we. In 1812, Bell started the Comet on the Clyde. This vessel was only of three horse power, but it was the first seen on the rivers, or from the shores, of Britain. Since that period, steam-boats have multiplied, of all dimensions, tonnage and power, and many improvements have taken place since the first attempts.

It would be useless to burthen these pages with a description of the various vessels which now ride along the shores of Great Britain, or leave the bosom of our noble rivers, and it would be equally futile to describe the vessels of other countries. All that need be stated is, that there are vessels from an unit horse power up to three thousand five hundred tons; the latter is the tonnage of the Great Britain. As she is the largest steam vessel in the world, perhaps it is well to insert her dimensions. The length of this "British Leviathan" is, from the figure-head to taffrail, three hundred and twenty-two feet; the length of keel, two hundred and eighty-nine feet; length of deck, three hundred and eight feet; breadth of beams, fifty feet, six inches; depth, from upper deck to bottom, thirty-two feet, six inches. The engines consist of four cylinders, of eighty-eight inches in diameter, and their length of stroke is six feet. The frames of the engines are a combination of hard timber, and wrought iron, arranged in a triangular manner, and connected firmly in every direction to the hull. There are one hundred and eighty state rooms; some are arranged for one person, but the greater number for two, and a few large ones for families. There are two large boudoirs, or private rooms, out of which access is gained to a number of sleeping apartments. The kitchen, steward's pantries, and other subordinate departments, are situated at such a distance from the part appropriated to passengers, that the latter may not be incommoded by the heat and smell arising from cooking. All that part of the vessel containing the boilers and coal bunkers, is partitioned off with iron, in such a manner as

to render it fire proof. She has six masts, the highest of which is seventy-four feet above deck; one thousand, seven hundred square yards of canvass; one thousand, five hundred tons of iron used in her construction; and that of boilers and engines displaces three thousand, two hundred tons. Fears were entertained respecting her great length, whether, in crossing the roll of the Atlantic, she will not be found deficient in strength of beam, but her performances have been good, and she has proved herself an excellent sea boat.

The power in a steam-boat engine is applied to turn an axis or rod, to which a wheel is attached. To the rim of this wheel a number of flat boards or floats are fixed, at regular intervals. When the wheel revolves, the paddle boards remove the water, the resistance of the element propelling the vessel. A portion of the wheel is constantly under the surface of the water, and by its revolution a continued impulse is given to the boat.

Condensing engines are generally used in steam-boats, on the same plan as the double-acting engine of Watt, differing in construction and relative position of the parts. In some vessels two engines are used, acting on a common axis, and with the crank so arranged, that when the crank of one is at the dead points, the other is in full motion. By this plan a tolerable uniformity of the motion is insured without the deformity of a fly wheel. In other boats only one cylinder is used.

The manner in which the parts are arranged will be understood by the following figures—6, 7, 8, 9. Fig. 6 is a view looking across the vessel; fig. 7, along it. The beam is below the

cylinder, not above it, as in land engines, and there are two beams, one at each side of the cylinder. The piston rod has a cross head (*d e* fig. 7) attached to its upper extremity, and passing over the cylinder in a transverse direction.

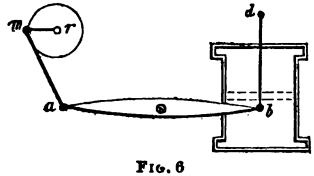


FIG. 6

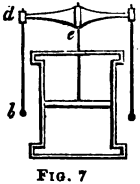


FIG. 7

In relation to the boat, from the ends of this cross head *d e*, rods hang down attached to the ends of the beams at their lower extremities, and playing on pivots at both their connexion with the cross head and beams. One of these, marked *d b* in fig. 7, which represents a view of the piston with its rod, cross head and side rods are seen looking along the boat. Fig. 6 is a side view, showing the piston, one side rod, one beam, and the situation of the crank and axis, or shaft, which turns the wheels. The beam is in the horizontal position, and the piston is exhibited by the dotted line in the middle of the cylinder. Figs. 8 and 9 will

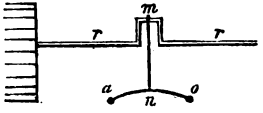


FIG. 8

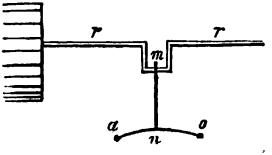


FIG. 9

illustrate the way in which the motion is transferred from the beams to the axis, *r*. A cross bar (*a o*) is attached to the extremities of the beams farthest from the cylinder. To the middle point (*n*) of this cross bar is fixed the rod (*n m*), which works the crank. The crank is double, two of its extremities being fixed in the axis (*r*), the other two ends of the crank are connected by a short transverse bar, to the middle of which (*m*) the rod (*n m*) is fixed. The paddle-wheels are firmly fixed to the rod (*r*), which communicates the motion to them.

The action will be understood with the aid of the preceding figures. The piston rod raises and depresses the cross head (*d e*, fig. 7), with which the side rods rise and fall, and these elevate and depress the extremities of the beams to which they are attached. The other ends of the beams, alternately rising and falling, carry the cross bar (*a o*) along with them, which, communicating its motion to the crank by the rod (*n m*), gives a continued circular motion to the axis, the extremity (*m* of *n m*) describing the circle shown by the dotted line in fig. 6. Figs. 8 and 9 show two different positions of the crank. This engine is very similar to the condensing engine of Watt.

VARIETIES OF STEAM-BOAT ENGINES.

Since the days of Watt, little or no improvement has taken place in the construction of the steam engine. Many alterations have been effected in its details, the object of which has evidently been to occupy as small a portion of the vessel with machinery as possible. The cumbrous beam has been dispensed with, and simplicity

introduced without adding greatly to the efficiency of the engine, as left us by his immortal genius. There are, at the present time, many varieties of the marine engine; and those denominated the "direct action" engines appear to be adopted by the generality of engineers—such as the "Gorgon," "Siamese," "Annular," "Steeple," and Bury's; the last is called a "nondescript species." That denominated the "Gorgon" has the connecting rod between the piston-rod and crank, whatever may be its subordinate features. The *Artizan* objects to this variety; it says that "only a very short stroke is attainable by this plan," and they believe "that an engine of moderate stroke will work more steadily and smoothly, than when the stroke is short, and the reciprocation rapid. There is also great waste of steam at the ends of the cylinder when the stroke is short, which ought not to be disregarded." This variety of engine involves the use of a large paddle-wheel, by the elevation of the shaft rendered necessary to afford room for the stroke, and the largeness of the wheel gives too great a velocity to the float-boards, by which means a considerable portion of the engine power is dissipated. Where there is great disparity between the speed of the wheel and the speed of the ship, a large amount of power is wasted in throwing back the water from the wheel, instead of its being employed in forcing the boat forward; and from this plan of engine, as applied to ordinary sea-going steamers, a serious loss from this source must perpetually occur, or else the engine must be working under its proper speed and power. This plan of engine

has been manufactured by Messrs. Boulton and Watt for the "Virago;" Miller and Ravenhill for the "Infernal;" Fairbairn and Co. for the "Vulture;" Sir J. Rennie and Co. for the "Samson;" Seaward and Co. for the "Prometheus;" Scott and Sinclair, and Robert Napier for other vessels. Fairbairn's is the most reputable "Steeple" plan. The engines of David Napier, also, appear to possess considerable merit, being very "compact and effectual," yet the protrusion of a large portion of the machinery above deck is an objection.

"Messrs. Maudslay and Field's direct action engines are objected to on account of an increased friction of the piston, increased leakage, and increased radiation, as well as imperfect fulfilment of the grand purpose of direct action engines—the saving of room." The *Artizan* is, perhaps, in error in the opinion here quoted; for among all the engines of the direct action variety, Maudslay's are the best. Great difficulty is found to exist in the "Siamese" engine to make the *twin* pistons move simultaneously. Any difference in the friction of the piston packings, or the stuffing boxes, arising from the one having been screwed up more than the other, will have a tendency to retard that piston in which the extra friction exists, and impart a corresponding twist to the cross head which binds the two piston rods together. Bury's engine is considered an odd contrivance, but this is the invention of Mr. David Napier. The most remarkable improvement introduced by Mr. Napier, is the "double-acting air-pump," which has been substituted for two air-pumps of the usual kind. A common objec-

tion to this description of air-pump is, that the air accumulates underneath the piston, but a provision is made to counteract this tendency, the bulk of the air-pump piston being made to travel past the *port*, so as to expel the air as well as water.

PENN'S OSCILLATING ENGINES

are very simple, and extremely effective. They are of the direct action variety, and experience has shown them to be admirable contrivances. "The steam enters a belt on the cylinder, through curved pipes adjacent to the ship's sides; from this belt it passes through the valve, by which means its distribution is regulated, and escapes from the cylinder to the condenser at the side of the belt opposite to that at which it entered. There are two air-pumps at an angle with the keel, and they are both worked by a single crank in the intermediate shaft; the due position of the air-pump rods being maintained by means of guides. The slide valves are provided with guides, and are wrought by means of an eccentric rod in the usual manner, but the eccentric is not attached immediately to the valve lever, but to a curved transverse link guided between the columns that support the shaft, and susceptible of a vertical motion. The curve of this link is concentric with the arc, described by the cylinder in its oscillation, and its design is to obviate the distortion that would result from the combined movement of the cylinder and eccentric. The columns of the framing are of malleable iron, and a malleable iron cross is introduced at each side of the engine, to give the framing greater stiffness. The starting

handles are so situated, as to be accessible from a stage situate near the level of the cylinder covers, and this stage is continued round the engine, so as to afford easy access to all parts of it. The hot wells are bolted to the mouths of the air-pumps, and rise as usual to a higher elevation than any other fixed part of the engine. Many objections have been urged against this plan of engine, but the best answer to such objections is to point attention to their almost universal adoption on the Thames and elsewhere. It was asserted that Penn's engines would not answer, excepting in boats of small tonnage, and for river navigation; but this objection has been refuted by the success of the two fifties placed in that magnificent and effective boat, the "Black Eagle."

SAMUDA'S BELL-CRANK ENGINE

is another contrivance. The cross head of each engine is connected by side rods in the usual manner to the beams, or rather half beams, and from thence it is conveyed through the medium of the connecting rods to the crank. There is only one crank for the two cylinders, the effect of the connecting rods being at right angles to each other is virtually the same as if there were two cranks so placed.

ROTATORY ENGINES.

It has been often stated, that a good rotatory engine, or an engine in which steam is made to act in a *circular* direction, has been long required; but from the days of Watt, not one has been produced. Borrie's engine may be of utility, but we doubt it much. In Boulton and Watt's

engine, in estimating the quantity of steam used, thirty-seven per cent. is allowed for friction, leakage, etc. Borrie allows only ten per cent. for friction, and nothing for steam wasted in filling passages. Many persons have produced rotatory engines, but their defects have been apparent, and they have been abandoned. Murdoch and Hornblower, 1807; Clegg, 1809; Turner, 1816; Eve, 1825; Earl Dundonald, 1844; and lastly, Borrie.

Messrs. Seaward have constructed a vessel on what they term the "Atmospheric" plan, which consists in working the cylinders open at the top, the pressure of the steam forcing the cylinder up, and the pressure of the atmosphere sending it down again. The "Wonder" has attained a very high rate of speed. The "Sapphire," another vessel on this plan, is considered a swift vessel. It requires twice the amount of cylinder capacity on this plan to obtain the same power, as by the old method; and there is twice the amount of piston friction, and a great cooling of the cylinder at every stroke, by contact with the atmosphere.

Mr. David Napier and Sir John Rennie, Brothers, have recently adopted vertical tubes in the manufacture of their boilers, which appear to answer well.

SMITH'S DIRECT-ACTION ENGINE FOR THE SCREW.

It has become of great importance to construct an engine which shall communicate the motion to the screw directly, instead of doing so through the intervention of machinery, which had been found requisite for the old mode of propulsion, but much of which is now in want of revi-

sion, to suit the arrangements of steam vessels. It is desirable that the vessel shall not be burthened with superfluous machinery, and that it should be protected from hostile shot while in action. Mr. Smith's engine consists of two steam cylinders, the piston rods of which are attached by suitable links to a main cross head, or beam, connecting both engines; forming a part of this cross head are two triangular frames of wrought iron, which serving the double purpose of side rods and connecting rods, descend one on each side of the cylinders, and are connected immediately with the cranks on the main shaft, lying between the cylinders, in a line with the keel of the vessel. The air-pumps are worked by the same arrangement of levers, which forms the parallel motion for the piston rods. The hot water and bilge pumps are worked by the air-pump.; cross-heads, in the usual way. The main shaft gives motion to the screw shaft, through the medium of a new multiplying gear. The engines are of 300 horse power; and every part of them is below the water line of the vessel.

Three vessels on the Thames, called the *Ant*, *Bee*, and *Cricket*—boats which profess to work with low pressure condensing engines. The public are not aware that they are working at 36lbs. on the square inch. The engines are by Joyce, two of fifteen horse power; the fuel consumed is only about 2 cwt. 1 qr. per hour. These are the penny boats, plying from Hungerford to London Bridge; and working at high pressure, they may, when out of order, blow up their decks and the myriads of passengers they are burthened with.

CHAPTER IV.

LOCOMOTIVE ENGINES.

In the locomotive engine the beam and condensing apparatus are omitted. The steam, forced on one side of a piston, is resisted by atmospheric pressure on the other. The steam must have an equal force to balance the air's pressure; it exerts no motive power until it exceeds that; therefore, it must have a pressure much higher than steam acting against a vacuum. From this cause high-pressure steam is generally employed. This steam, after exerting its power, rushes from the cylinder through the steam pipe, into the atmosphere, and the noise and din of this is what is so often the subject of conjecture, with those unacquainted with the mechanism of locomotive engines.

The first application of locomotive power on railroads, was on the Stockton and Darlington line, for conveying goods and passengers, which was opened in 1825. The total weight of the engine, waggons, and passengers, was eighty tons, and moved at fifteen miles an hour. This was on an incline, coming under the second class in point of gradients. But the first engine that ever appeared started on the railroad at Merther Tydvil, South Wales, and was built by Trevithic and Vivian, of the Hayle Foundry, Cornwall. The engine started in 1804, and was successful. This contrivance was not superseded for nearly thirty years. The engines of Blenkinsop and Chapman,

were laid aside on account of the great force and friction to be overcome. It was Hadley, formerly of the Wylam colliery, that the merit is to be ascribed of ascertaining and establishing the fact, that the adhesion, or friction, of the wheels with rails on which they moved, was sufficient to propel an engine, and that progressive motion could be obtained without surging, or slipping of the wheels on rails.

It was not, however, until 1830, that the public became aware of the benefits of railway locomotion, and that was on the opening of the Manchester and Liverpool railway, on which that celebrated statesman, Huskisson, lost his life. The engine of Trevithic had the cylinder placed horizontally, and parallel with the line, with cranks on the axle; and the inventors supposing, as subsequent inventors have also thought, that the traction of the wheels would not be sufficient for the propulsion of the carriages, laid a toothed rack parallel with the line, in which it worked a toothed wheel fixed on the cranked axle. The first trial which was afforded this engine, it dragged after it carriages containing ten tons of iron at five miles an hour. The greatest speed obtained on the Stockton and Darlington railway, was eight miles an hour.

The Manchester and Liverpool railway company were for some time undecided whether to adopt the system of traction by ropes drawn by steam power, or locomotives. They offered a premium of five hundred pounds for the best locomotive engine; and the conditions were, that the engine should draw three times its own weight at ten miles an hour, with a pressure on the boiler not

exceeding fifty pounds on the square inch, and the weight to be six tons. Mr. G. Stephenson produced the "*Rocket*," with a tubular boiler; and it electrified almost every one by its speed of twenty-nine miles an hour. Other engines were soon after constructed on the model of the Rocket, which attained the speed of sixty miles an hour! It was supposed, previously to these achievements, that to travel so rapidly would take away the breath; but this notion was soon exploded. Many improvements have taken place since the construction of Stephenson's engine, but the weight has increased from four and a quarter tons, to fifty-nine tons, with, of course, a greater wear and tear of speed in the general traffic. The fact is, that in the present construction of locomotive engines, there is a rapidly-increasing loss of power, with *increased velocity*, and the actual rate by which passengers are conveyed on most lines of railway does not exceed the speed at which they were conveyed on the Liverpool and Manchester railway, in 1830.

At the Broomsgrove station, on the Bristol and Birmingham line, a leviathan engine has just started of gigantic dimensions. This engine is called the Great Britain, and possesses a power equal to one thousand tons on level rails. This engine has ascended the Lickey incline with 150 tons—a gradient of 1 in 37. The dimensions are thus: diameter of cylinder, eighteen inches, length of stroke, twenty-six inches. It has six wheels coupled, forty-six inches; having a tank over the boiler for supply of water, and a foot plate sufficient to hold boxes for coke necessary for a trip up and down the incline. This engine is used daily.

Another collosal engine of fifty-nine tons has lately been constructed called the Great Western, on the broad gauge—its performances have, if we are to believe newspaper reports, been very great, attaining an average speed of sixty miles an hour.

CAUSE OF ROCKING IN RAILWAY CARRIAGES.

When the engine is travelling thirty-three miles an hour, the top of the wheel is thrown forward at the rate of ninety-two feet, and downward at the rate of forty-six feet, in a second. Railway carriage wheels are frequently six to seven pounds heavier *on one side than the other;* and it is no wonder, therefore, that the unpleasant motion experienced while travelling in carriages so circumstanced, is so often complained of. To remedy this, Mr. Heaton constructed a model, in order to show how rocking could be obviated. This model is made to represent the wheels and axle of a railway carriage, the axle being sixteen inches long, and the wheels six and a quarter inches in diameter. By placing some loose pieces of iron inside the rims, so as to represent wheels, which are one-sixth of an inch thicker on one side than the other, the thick side of one wheel being placed opposite the thick side of the other, at the opposite ends of the axle, according to the common practice, and the wheels allowed to revolve, the model will continue to jump about the table on which it is placed, so long as the wheels are in motion. Again, if the pieces of iron be all placed on the same side of the centre, the model will not rock as before, but jump up and down, and make more evolutions than in the last case. The wheels, being perfectly equilibrated, will revolve without any oscillating

movement, and the frame remain quite steady, the number of revolutions with the same power being considerably increased. In the recent construction of railway carriage wheels, we believe, this rocking motion has been remedied by the above contrivance.

RAILROAD WHISTLE.

When any locomotive approaches a station, or a tunnel, a shrill whistle is heard, which startles many a sleepy passenger from his slumber, and causes him frequently to conjecture how this sound is produced. This whistle is used as a precaution on entering tunnels, in order to warn workmen that may be employed in repairing the rails. It is also sounded to prevent collision with other trains that may have entered the tunnel. It is produced by the turning of a cock, which permits steam to rush through a small aperture with great velocity against the rim, similar to an inverted bell, which collision causes the sound.

STEAM CARRIAGES FOR COMMON ROADS.

This scheme has often been attempted, but hitherto without success. Dr. Robison, the friend of Watt, Mr. Evans of America, and the great Watt himself, suggested the idea of using steam carriages for common roads. Trevithic, in 1802; Griffith, in 1821; Gordon, in 1824; Seawards, and Hill, and Burstall,—all attempted to construct engines, but were unsuccessful, until Mr. Gurney's patent of 1827. The failure of the last project was referred to heavy tolls, obstructions on the roads, &c. The carriage, constructed by Goldsworthy Gurney, plied between Gloucester and

Cheltenham four months. Mr. Gurney stated, in a petition to parliament on this subject, that he travelled steadily twelve miles an hour, and that the extreme rate he has run was between twenty and thirty miles an hour. Mr. Hancock, Mr. Ogle, Mr. Stowe, and Mr. Farey, all gave evidence in favour of this scheme.

The *Artizan* says, "The great difficulty heretofore experienced to the success of steam carriages on common roads, has been the impracticability of hanging them on efficient springs; for, at the same time that there must be a rigidity between the cylinder and the axle to transmit the engine power, there must be a *flexibility* to enable the springs to act. If the springs be impeded, or are too strong and rigid, the machinery will soon be knocked to pieces, in consequence of the irregularities of the road; while again, if we suppose the springs to be sufficiently elastic to obviate this evil, and that the cylinder and axle are directly connected, the springs will yield with every stroke of the engine, and the alteration in the relative positions of the axle and cylinder, consequent on their movement, will cause the piston to strike with violence the top or bottom of the cylinder. The striking of the piston may indeed be obviated by making the cylinder of an extra strength; but this again involves the evil of a great waste of steam, and introduces excessive complexity into the valve gearing." Until these difficulties are overcome, steam coaches cannot be successful. Railway carriages manage to proceed on bad springs, but this is not the case with coaches on common roads; they must possess good springs, or they will not do at all. Good springs are,

therefore, indispensable, even if wood paving on our highways were more generally adopted, to enable steam carriages to travel successfully on our common roads.

The progress we are making in railway legislation, renders these carriages useless, the act regulating the prices of transit, by fixing the rate of one penny per mile for third class passengers, was a judicious one; but we contend that Parliament should have struck deeper to the root of monopoly, and fixed the rate at *one halfpenny* per mile, and then we should have more nearly assimulated our rates to those railways of the continent. Why should our charges be more than the rates on the continent? the answer is, that our costs of construction are larger. Why is this? because the railways of England are in the hands of private parties, while the railways of the continent are in the possession of their respective governments.

If a person travels in a third class carriage, he is subjected to every annoyance, even the clerks at the stations throw the tickets to him, and receive his money as if he was an inferior creature. At the London termini of the Croydon line, a Mr. Peter Clark has actually shifted the pay office of the third class to a cold stone passage, open at both ends, through which the wind rushes with a force sufficient to cause every muscle to quiver with cold.

CHAPTER V.

ATMOSPHERIC RAILWAYS.

It is a matter of extreme regret to all lovers of science, that individuals are in existence who consider it necessary to exercise the power which an accident may have afforded them, to denounce schemes yet in their infancy—projects which are in themselves beautiful instances of the genius of man, illustrating the power of the human mind, its elevated conceptions, and the invariable tendency for progression it evinces. Yes, it is to be deplored, that persons wielding the power of the press misuse it, for the purpose of injuring those who dedicate their intellectual energies to elicit truth, and to demonstrate that there are elementary powers existing which can be made useful to mankind; thus exhibiting bright manifestations of the genius of our race. We say that an editor of any paper attacking an infant science with unjust virulence is a common enemy, and should be treated as a creature desirous of impeding man's holiest aspirations after excellence! Perhaps amongst all those projects which have in modern times been brought before the public, no scheme has been more abused than the plan of atmospheric traction. Had this abuse been the result of observation, or founded on a regard for the interests of science, then, in that case, we should have condemned the tone in which the editor of *Herapath's Journal* has treated the Croydon line;

but when we know that all this virulence has been lavished on the atmospheric principle from paltry, *private* motives, we cannot command language in which we can adequately express our contempt for such injustice. We inform the editor of this journal, that his mean abuse of this system is caused by Mr. Wilkinson or Mr. Samuda refusing to permit him to have the advertisements of their line for his journal. This is not an insinuation, for we openly charge the editor with having written for advertisements, and, further, that he was *refused* them. Hence his illiberal and vulgar invectives against atmospheric traction. The *South Eastern Gazette* has honourably distinguished itself, by exposing Herapath and supporting the system. It is true that the atmospheric principle requires persons possessing experience, judgment, and a philosophic temperament, in order that it may be successfully tested, and the managers of the Croydon line have judiciously chosen Mr. Alexander Smith as their mechanical engineer—a gentleman who thoroughly comprehends the principle and details of the plan; and we regret that such a practical man does not possess greater power, for certain we are that under his auspices the system would flourish and defy detraction. Within the last five months the trains have been running on the Croydon line successfully. It is true that there are instances in which the trains have stopped, but the causes have been such as not to affect the principle of the plan.

About five months since the trains were discontinued for six weeks, in order that a new continuous valve might be laid down on the aperture

in the tube. The engines at present constructed are three in number, with a distance of two miles and a half between them, that is, Forest Hill one pair of fifties, Norwood the same, and lastly, Croydon a pair of equal power. These engines do not answer the purpose for which their manufacturers or the company designed them, and they are continually out of repair. This is one of the principal causes of the stoppage of the trains. The vicinity of Forest Hill and Norwood is inconvenienced by a want of one of the principal elements, either in stationary or locomotive engines—water. This is another of the causes of the irregularities in the transit, and which have been so heedlessly charged as failures in the principle. There are also other causes which will account for the interruptions in the traffic. In order to obtain a sufficient vacuum, the tube must be kept air tight, or nearly so, and therefore it was indispensable to lay down a good continuous valve. This was effected about six months since. The old method of applying a composition of bees' wax and sterine, did not answer, and Mr. Samuda very judiciously abandoned this stuff, but in doing so he adopted at the re-opening of the line a yellow mixture, of burnt earth, sterine, and bees' wax, manufactured by Mr. Johnson, which the inventor patented. On the very first experiment of this compound, it utterly failed, and after being tried about three weeks was abandoned. Another composition was then manufactured by Mr. Hubback, composed of train oil, solution of india rubber, sterine, &c.; this composition hardened very quickly, although altered four times, and it will, no doubt, give way before a composition

which we have examined, and unhesitatingly pronounce it will succeed.

It is the production of an able manufacturing chemist, Mr. Henry Hobbs, of Great Guildford Street, Southwark, and possesses all those properties which the atmospheric system requires. We have carefully tested it. It will bear 140° of heat, and will not harden, but possesses great elastic power at 32°. It is adhesive, and will attach itself to cold iron with the force of a vice, but it will not adhere to the copper heater. It possesses a fine surface, and will seal similar to wax, but without its brittleness. It is also of great strength, and cannot be sucked in through the joint plates or valve. It does not contain any earthy substance, and ten tons pressure will not cause any exudation through paper or linen.

The writer, five months since, waited on Mr. Samuda with Mr. Hobbs' composition, and explained its properties to him. Mr. Samuda, on that occasion, placed the stuff manufactured by Mr. Hubback before us, when we stated that it "was not enduring, would harden, and that the oily matter would exude by the operation of the atmosphere." Mr. Samuda bluntly told us we did not know the nature of the composition. We pressed Mr. Samuda to grant Mr. Hobbs a trial, and he consented. We informed him, that the composition could be made so as not to require the copper heater during the summer months. This assertion caused a smile at our simplicity. The stuff manufactured by Mr. Hubback was laid down from Forest Hill to Croydon; and judge our astonishment, when we perceived the heater removed, as the heat caused this abortion to run similar to train oil into the tubes.

We thus perceived that our poor judgment had been deferred to, for the copper heater was abandoned. Mr. Hubback's stuff failed, and this has been another cause of stoppages, and yet Mr. Samuda is now laying it down on the new valve, from Forest Hill to New Cross!

We have a sincere desire to incite Mr. Samuda and Mr. Wilkinson to adopt those means which will insure success of the scheme of atmospheric traction, and without an effective composition the principle cannot be successful, but with a good one must succeed, and sooner or later the gentlemen who manage this line will adopt the composition invented by Mr. Hobbs. We regret that four months have been permitted to pass without a trial, thus causing the enemies of the plan and the unscientific world to imagine an entire failure in the principle.

With respect to want of water this defect can be remedied by boring beyond the chalk formation to the reservoir, that is known to exist around London—tapping this, which is about 350 feet beneath the surface of the crust of the earth, the limpid element would rise one hundred feet, and steam power could be used to raise it the remainder of the space. The company could not only supply their boilers efficiently, but a population of two millions of persons, with a pure element so much required. With regard to the engines, we think Messrs. Maudslay and Field have in this instance, as well as in some others, trifled too much with a reputation which deservedly ranked the highest in the profession. We are sensible that the talents of Mr. Field are of the highest order, and we deeply regret his failure in the construction

of these engines. It is no defence to plead that defective drawings and instructions were given him. This is not true; he ought to have known what was required as well as those persons who furnished them.

Mr. Field was offered by Mr. Samuda all the practical information he and his firm possessed, in order to enable him to construct efficient engines; but Mr. Field rejected the light of experience in this matter, and rushed into dim theory, which has been lamentably apparent in the want of strength of almost every part of the machinery, thus causing frequent irregularities in the transit. Boulton and Watt are to furnish engines for the Epsom branch, from drawings executed by Mr. Samuda, and we have no doubt when these engines are constructed, that few complaints will be urged against their efficiency.

We say then, down with the present engines, and erect sufficient ones, place a good composition on the continuous valve, such as we have described, procure an abundant supply of water from deeper boring, and the principle for which we have for years contended—the plan in whose defence we have so frequently flourished our grey goose quill to support, will, by its regularity, speed, cheapness of construction, economy in working, and far above all, safety in travelling, drive for ever the puffing monster from our smiling fields, beautiful vales, and sterile heaths, and instead of having continually to place on record the disastrous and appalling accidents which spread desolation amongst hundreds of families, we shall only have the pleasing duty to observe confidence in the minds of the public where now reigns terror and dismay

In all ages, and in all civilised countries, where the slightest glimmerings of science has illumined the darkness of ignorance, the power of air, and its pressure upon all created things, has been known, and frequently applied as a propelling and a lifting power. The rudely constructed vessels of the ancients were propelled with air bellying out a broad display of canvass, or other substances; and in the early attempts to raise water for fountains, as jets, or from mines, atmospheric pressure was the first agent employed.

Although the scientific men of other lands have left abundant evidence of their knowledge of the powers of air, fire, and water, and have exhibited in their writings, that they were aware that fire applied to water would create steam, yet they did not adapt this powerful agent to the purposes for which an all-wise Providence evidently intended it. If, therefore, vessels have been propelled by air, rushing with force against a resisting surface, why should not the atmosphere, by its ascertained properties and power be made an important agent in dispensing with the immense quantity of fuel now consumed, and remedy the loss sustained by wear and tear of railroad gear?

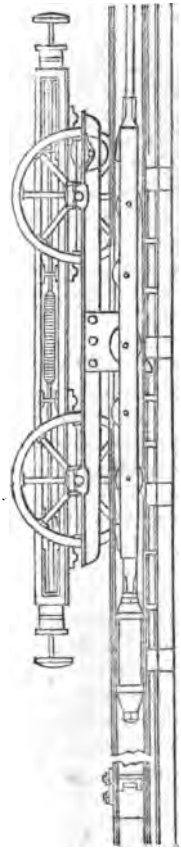
If atmospheric propulsion be practicable—and we have now, in the Dalkey branch of the Dublin and Kingstown, and the Croydon lines, sufficient proof that it is—the advantages to the people will be of great magnitude, not probably in the first few years of its adoption, because the cost of laying down the tubes and valves, with the expense of composition, and constructing stationary engines, air-pumps, and stations, will be very considerable. But in dispensing with the locomotive

engine, and its consumption, and the danger of collision, great and important benefits will accrue, which posterity will feel and appreciate.

Vallance was the original projector of the system of atmospheric pressure, which has succeeded at Dublin; and judging from this short line, and the success of the "Bristol Junction," it is reasonable to believe that a more extended railway will prove equally successful; and the Croydon company's Epsom atmospheric branch to London, a distance of twenty-one miles, will decide this question. Seven miles of this rail has been opened for passengers and traffic.

DESCRIPTION OF ATMOSPHERIC RAILWAYS.

In the atmospheric railway, a pipe of about fifteen inches diameter is laid between the rails on which the carriages run, this pipe is exhausted at once by an air-pump; a travelling piston is forced along it by the pressure of the atmosphere. A rod connects the piston with the carriages, traverses a slit on the top of the pipe. The great difficulty to be overcome is to cover this slit with a substance which would render it air-tight, and yet permit the connecting rod to pass without offering obstruction. The opening at the top of the pipe is covered by a continuous valve, extending its whole length. It is formed of leather, riveted between steel plates. The upper plate is wider than the slit, and prevents the leather being pressed in by the pressure of the atmosphere; the lower plate just fits the slit, and is curved to the shape of the pipe; one edge of the leather is fastened to a longitudinal rib cast along the opening, and forms a hinge as on a common pump



valve. The other edge of the valve, when it covers the opening, forms with a ridge cast on the pipe, a channel, or trough, on its whole extent. This trough is filled with a composition which adheres to the side valve to keep it air-tight. As the travelling piston is forced along the pipe, one side of the valve is raised by four small wheels fixed behind the piston, so as to admit the connecting rod to pass. The opening thus made also admits the air to act against the piston. The rupture in the composition ought to be sealed again before the train passes.

A steel wheel, regulated by a spring, is attached to the carriage, and presses down the valve immediately after the connecting arm has forced it open; and a copper heater, about five feet long, filled with burning charcoal, should pass over the composition, and melt it; thus leaving the valve air-tight as before, and ready for the next train. A protecting cover, formed of thin plates of iron, about five feet long and hinged with leather, is placed over the valve to protect it from rain and dust. Each tube is about two and a half

miles in length, with a stationary engine for each length of piping, to exhaust the air; and an arrangement is made, by means of which the piston, as it approaches the end of the pipe, opens the throttle-valve, which admits it into the next length of piping, so that the train may proceed from one station to another without stopping. The tractive force is thus evidently derived partly from the pressure of the atmosphere on the piston; its amount will depend on the area of the piston, and on the extent to which the exhaustion of the air can be carried by the air-pump; therefore the difficulty of keeping the pipe air-tight increases with its length, and with the pressure obtained. The tube on the branch of the Birmingham, Bristol, and Thames Junction Railway, where this system has been in operation for more than five years, is nine inches internal diameter, and but half a mile long. It is on an incline of part 1 in 120, and part 1 in 115. A vacuum equal in some instances to a column of mercury 23½ inches high has been obtained, and loads of thirteen tons have been propelled at a speed of twenty miles an hour. On the Dalkey branch of the Dublin and Kingstown Railway, the tube is fifteen inches in diameter, and the length is one mile and a quarter. The average incline is 1 in 100. The exhaustion has been extended to 22½ inches of mercury; and three carriages loaded with passengers have been propelled up the incline, at the rate of forty miles an hour. We have frequently travelled on the Croydon line with two carriages at the speed of eighty miles an hour, with the mercury at 23.

LOCOMOTIVE TRACTION AND THE ATMOSPHERIC SYSTEM CONTRASTED.

Admitting the practicability of the atmospheric system, the advantages it offers are greater compared either with the locomotive system, or the plan of traction by ropes, drawn by stationary engines. The locomotive system requires the impelling the weight of the moving power, which amounts, engine and tender together, to above twenty tons, or one-third of the average weight of a loaded passenger train of carriages. The alternate motions of the pistons are so rapid, that the orifice of the blast pipe requires to be so contracted, that the waste of steam cannot escape in sufficient time to prevent its reacting on the steam, as it enters the cylinder at the other side of the piston. So great is the loss of power by locomotive engines when in rapid motion, that an engine, which on level rails will draw a load of 346 tons at the rate of 10 miles an hour, will only draw 108 tons when the speed is doubled; and but 30 tons, at 30 miles an hour. Thus by doubling the speed from ten to twenty miles, the power is diminished more than *three* times; and by trebling the speed from ten to thirty, the load propelled is diminished to little more than *one-twelfth* of the amount. A third disadvantage is the wear and tear of the rails, caused not only by the great weight of the engine, but also by the circumstance, that the rails constitute the *fulcra* whereon the leverage is obtained for propelling the train, consequently they must be liable to great strain and friction, especially in curves, when the radius is great, and where there are any

inequalities in the road. The frequent derangements of the machinery of the engines, and the numerous repairs necessary, are also serious impediments to the locomotive system, and add materially to its expenses.

The atmospheric system, on the contrary, is exempt from these disadvantages; but it has to encounter the friction of the travelling piston, the loss of power from leakage, and wear of the continuous leather valve. The projectors of this system have considered the pressure of eight pounds to the square inch as so much tractive force to be applied, without deduction, to the propulsion of the trains. They estimate, that the mainpipe, eighteen inches diameter, will contain a piston 254 inches area, and assuming an average vacuum equal to produce a pressure of eight pounds on the inch, attractive force of 2·032 pounds is calculated upon, which will draw a train weighing forty-five tons up an incline of 1 in 100. A stationary engine, 110 horse power, would, it is stated, be adequate to exhaust a pipe of that diameter, two and a half miles long, in four minutes, and trains might be started each way every quarter of an hour, and convey 5,000 tons daily. The loss from leakage is admitted to be very great by Clegg and Samuda, amounting to an eighth. On the half-mile length of pipe on the Bristol and Thames Junction, one-eighth part of the power is estimated to be employed to overcome the leakage of the piston and valve; for when the engine is at rest, the vacuum is destroyed in eight times the number of minutes required to exhaust the pipe. Friction and leakage are certainly drawbacks on the amount of

tractive force actually gained by the atmospheric pressure. Nevertheless, it appears, on the short lines, where the system has been tried, that the effective force of the stationary engines far surpasses the tractive force that could be gained by the consumption of the same weight of fuel in locomotive engines.

The South Western Company are constructing a continuation of their line to Hungerford Bridge, at which place there will be erected a termini, at a cost exceeding £100,000. The expense of the short line will exceed £600,000, or £350,000, per mile!

Germany has now 37 lines of railway, 469½ miles; there are at work 600 engines, 267 English, 39 American, 46 Belgian, 16 French; remainder, nature productions.

It appears, from experience, that the costs of constructing railways on the continent are not less than in this country. Our costs of construction, on an average, did not exceed £32,000 per mile, and some of the estimates on which bills were obtained last session (1846), were £18,000 per mile. It is well known, that the Belgian and French lines are chiefly constructed by their respective governments, and in some instances they are single lines, and the traffic is not half so great as in this country. Singular that while the foreign lines cost working 49 per cent. on the receipts, the cost in this country does not exceed 34 per cent. It is asserted that the shortest continental lines pay best. In England the longest pay most. English capitalists hold 600,000, out of every million of money invested in Belgian or French lines.

COST OF CONSTRUCTING ATMOSPHERIC LINES.

Messrs. Clegg and Samuda calculated that a saving of £22,880 per mile could be effected in forming and furnishing their railway. They assumed as the average cost of formation, £37,000 per mile; but if a single line of rail be laid down with rather steeper gradients, it has been shown that such might be formed for £17,000 per mile. The extra cost of the tube would nearly counterbalance the saving effected by the steeper inclines, up which the atmospheric railway might be carried; and the cost of the fixed engines, air-pumps, and engine houses, would equal that of the outlay for locomotive engines. The annual expenditure on the atmospheric plan would be less than the locomotive. The cost of the tractive power, and repairs of the apparatus, are estimated at one-third that of the locomotive department of common railroads. The annual saving per mile on the atmospheric system is stated at £1,460. In point of safety, the atmospheric is far preferable. No collision of trains can take place whilst travelling, and the only accidents that could occur, would be at the junctions of the pipe, and these would be rare, and only rise from gross neglect.

TRACTION BY ROPE.

Let us compare the pneumatic principle of traction, with that by rope, to which plan it bears resemblance. In working effect, air far surpasses the rope of hemp or iron. The weight of rope for a length of only one or two miles, is nearly as great as a locomotive en-

gine, consequently there is no saving of load by traction. The rope that formerly drew the trains from Euston Square to Camden Town, weighed eleven tons, and the distance is only one mile, two hundred and eighty yards. The old rope on the Blackwall Railway weighed forty tons, or more than the average weight of the trains. The weight of a rope, its friction against the sheaves, and the frequent fractures, are difficulties and inconveniences to prevent the adoption of that plan of traction, and in comparison the atmospheric system stands conspicuous and pre-eminent. The latter system is capable of being applied so as to afford a cheaper, safer, and a more convenient mode of conveyance than locomotive railways, as at present constructed.

The rope system is now giving way before the light of science. On the Glasgow and Edinburgh line, the rope has been abandoned for an engine of twenty-two tons weight, constructed under the direction of Mr. Paton. The incline is more than a mile through a tunnel to the Cowlairs station, and the stationary engines were from ten to twelve minutes drawing a dozen carriages up the gradient, which is one in forty-two. The engine performs the duty, with seventeen to twenty carriages, in five to six minutes. The second day after this powerful engine started, the writer stood behind the puffing monster, with Mr. Paton, Mr. Miller, the engineer of the line, and Mr. Walter Buchanan, the editor of the "Glasgow Practical Mechanic." The engine performed the duty in the time specified; and, in returning down the incline, the break answered extremely well. The Birmingham have followed the example set them

by Mr. Paton, and have abandoned the rope on their incline from Euston Square to Camden Town, which is a gradient of one in eighty, and about the same distance as the Glasgow and Cowlairs line.

Mr. Pilbrow asserts, that, in his system of propulsion, all leakage is avoided; but this ingenious person does not say how this is effected. Clegg and Samuda admit that a power equal to that of ten horses per mile is necessary, whether for heavy or light trains, to pump out the leakage. It is said that the temperature of the air, on leaving the exhausting pump, is increased 200 deg., and that there is certain absorption of power consequent upon this increase of temperature. It is worthy of remark, that this scheme of atmospheric propulsion was formerly considered as visionary, but is now about to be made one of the greatest practical utility. The first proposition, however, was, that the *carriages and passengers should pass through a large tube propelled by the exhaustion of the air at the other end of the tube.* This plan was actually suggested by Mr. Vallance, but altered by Mr. Pinkus into something like the present system.

When Medhurst, Vallance, and Pinkus abandoned their schemes of propulsion, Clegg and Samuda introduced continuous valves, closed them by a mixture of sterine and bees' wax, to obtain a vacuum. Mr. Barry Gibbon says, from experiments instituted at Wormwood Scrubbs for two years and a half, previously to the tubes being laid down at the Dalkey branch, that the train could start in one minute after the engine commenced working to cause a vacuum, and that a load of

fifty tons had been propelled up a gradient averaging one in one hundred and fifteen; and a maximum velocity of nearly fifty miles an hour had been obtained with an engine of one hundred horse power, using as a divisor sixty-six thousand pounds raised one foot high in one minute.

In no instance, in which the atmospheric system has been tried, has it failed, but the mode of propulsion exceeds the expectations of its projectors. It is true that two engines of fifty-horse power are required for every two and a half miles, and the fuel consumed is considerable; but the quantity cannot be compared to the consumption of fuel on the locomotive plan; therefore, in point of expense, the atmospheric system is preferable. There are upwards of ninety engines required on the railroad between the Euston station and Birmingham; and there would be required for the same length of an atmospheric line, no more than sixty stationary engines that would work at the same speed and power. As regards safety (which to the public, is the most important point), the atmospheric presents every advantage.

The frightful accidents which are continually occurring on many of the railroads, are sufficient to induce the philanthropist to find means to prevent such loss of limb and life. After duly weighing the advantages and disadvantages of both systems, we are compelled to give our vote to the atmospheric principle. With regard to its practicability, there can now be no doubt; for every person can satisfy himself of this fact by inspecting the Croydon Railway, which, although exhibiting some irregularities, will ultimately, under unprejudiced and [illegible]tened management, succeed.

COMPRESSION OF ATMOSPHERIC AIR.

William Evans, of America, has, by means of enormous compression, succeeded in liquifying atmospheric air, which, with a few drops of a chemical composition poured into it, sufficed to make it resume its original volume. A train of twenty loaded waggons was transmitted a distance of sixty miles in less than an hour and a quarter; the motive power being the liquid air, enclosed in a vessel of two gallons and a half measure, into which fell, drop by drop, and from minute to minute, the chemical composition in question. The inventor declares, that an ordinary packet boat may make the passage from Philadelphia to Havre in eight days, carrying a ton of the liquid air. A steam engine of six horse power will produce that quantity in eight hours.

RAILWAY WITHOUT FIRE OR STEAM.

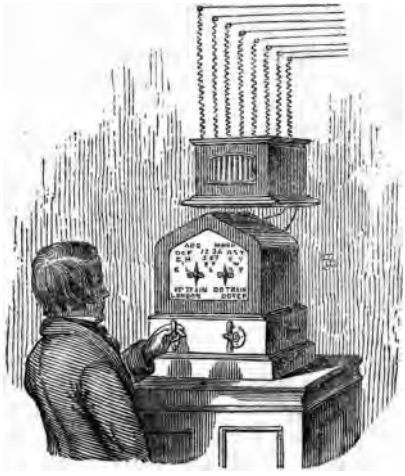
The proposed railway from Callao to Lima, in Peru, will not require the aid of steam or fire. The ground is an incline the whole of the distance. Above Lima flows the river Limac, which passes through a part of the city in its course to the sea, near Callao. This river is not navigable, yet it affords at all seasons of the year a hundred times the water-power necessary to work any traffic that can possibly come on the rail. The saving of expense in fuel is thus effected, and the cost of constructing the engines, and charges for management, avoided.

Before closing this chapter, we may observe that the atmospheric system is introduced into France, Italy, as well as in South Devon; and one is contem-

plated for Mid Kent. The line from Paris to Rouen has a tube of 28 inches diameter, and gradients of 1 in 30. The Italian Railway is nearly completed; and the South Devon is only waiting the experiments on the Croydon, relative to the best composition to start the piston carriages. We think the French Railway will prove very superior to any yet constructed, as there will be a greater piston area for the atmosphere to act on, and the steep gradients will be of great advantage.

The steepest gradient on the Croydon line is from the summit of the viaduct, between Norwood station and Croydon; this is 1 in 50. On the bank, *i. e* between New Cross and Forest Hill, is 1 in 100.

At the Norwood station is erected a *vacuum crane*, constructed under the direction of Mr. Joseph Samuda, an ingenious contrivance, whose enormous power is derived from vacuum caused by the exhaustion of air. This machine is capable of lifting ten tons.



CHAPTER VI.

THE ELECTRIC PRINTING TELEGRAPH.

ELECTRICITY is indeed a mysterious science, and it has now become a powerful mechanical agent, and also important in its various appliances for beneficial purposes. Electricity is more instantaneous, and travels with greater velocity than light. It is computed that if a continuous communication could be effected for a great distance, that intelligence might be transmitted 288,000 miles in a second. Professor Wheatley states, that in order to view the image of a spark,

he reflected it from a plane mirror, which, by means of a train of wheels, was kept in rapid rotation on a horizontal axis. The number of revolutions performed by the mirror was exactly ascertained by means of the sound of a siren connected with it, but still more successfully by that of an arm striking against a card; and it was discovered to be eight hundred in a second of time. When the spark was made to pass along a copper wire half a mile in length, interrupted in the middle and at both extremities, so as to present the appearance of three sparks, each gave a spectrum considerably elongated, indicating a duration of the spark equal to the 24,000th part of a second. The rate of movement, it is fair to conclude, according to this and other data, of a spark from any electrical machine is equal to 288,000 miles in a second, as before stated. This is a beautiful experiment, and has had the effect of electricity being made use of so generally, where rapid intelligence is of importance.

Signori Nobili and Antinori, threw out the following:—"*Is a current of electricity to be considered as depending upon the motion of a fluid denominated electricity, or is it the mere passing of vibrations?*"

Peltier states that pressure and swiftness are uninfluential on the effects produced, and that the quantity of electricity is in proportion to the swiftness, whatever the pressure be. In explanation which he has given of facts observed, he has deducted the electricity, which recombines at the very source where it is liberated when no obstacle to this recomposition is present. "It is," says Becquerel, "from want of having made allowance

for this recomposition, that other persons have been equally led into error in the explanations they have given of the phenomena produced in the liberation of electricity by friction. In fact, the following considerations ought never to be forgotten: 1st. When the decomposition of the two electricities by friction is brought about more rapidly than the recomposition, the electric tension increases. 2nd. If the recomposition is made in an appreciable space of time, the faster we turn the higher will the maximum tension arise. It is very evident that when we turn rapidly a certain point is attained, at which the tension of the liberated electricity is such that a portion of the two electricities combine, notwithstanding the bad conductibility of the bodies rubbed; the same will be the case in proportion as the intensity increases. Hence there must be a certain maximum intensity which cannot be passed, seeing that the two electricities always recombine on contact, the friction not being so instantaneous, that the separation of the two bodies can be effected in an infinitely small space of time. Whence we may comprehend that the disengagement of electricity is independent of the pressure, and of the swiftness of the friction.

Mr. Bain discovered that an effective voltaic battery might be formed by employing the moisture of the earth as the exciting fluid; and that, at whatever distances apart the generating plates may be placed, an electric current is formed, when communication is made between those plates by an external conducting wire. Mr. Bain has applied this discovery to work his electric printing telegraph with complete success.

The application of electricity as a m s of telc-

graphic communication, was known and effected nearly forty years since. Sommering was the first to employ electricity in telegraphic communications. In 1807, he constructed a model in the University, at Munich, which proved useless. Techner published some calculations demonstrating that a galvanic battery might convey signals forty miles. In 1833, Gauss and Weber instituted a series of telegraphic communications respecting certain simultaneous observations that were making between the Observatory and the Physical Institute, at Gottingen. This telegraph had only two wires, about two miles in length, suspended on posts. It worked successfully for more than a year. Mr. Ronalds, in 1815, succeeded in working his telegraph by a single circuit, through eight miles of wire. He also employed means adopted by Mr. Bain, of a train of wheels worked by weights, and used electric force principally for setting the apparatus in motion at the required times. In 1830, M. Ampère suggested the application of the power which a current of voltaic electricity possesses of deflecting magnetic needles to the purposes of telegraphic communication, and upon this principle most telegraphs since constructed depend. The plan first followed was to fasten small screens to the ends of nicely balanced magnetic needles, and by employing several such needles, and by having wires from the voltaic battery to each, when the electric current was made to pass over any one of the needles, on completing the communication between its governing wire and the battery, the consequent deflection of the needle removed the screen, and exposed the required letter, or symbol,

underneath. The number of wires required by this method, and their liability to get out of order were great obstacles to its efficiency. Mr. Bain discovered that one wire can be made effective in all weathers, and no return wire is required to transmit intelligence. M. Arago and M. Brequet have eulogised this plan, which has been patented by M. Broggett.

Professor Wheatstone's plan depends on the same principle, but he obtained great advantage by employing a dial-plate with symbols, to which the deflected needles point, instead of using screens with the symbols beneath. By an improved dial-plate, and the mode of working, he was enabled after the telegraph was perfected, to diminish the number of wires; and instead of using six, one was sufficient, employing the conducting property of the earth to complete the circuit.

The superiority of the printing telegraph over a signal telegraph, consists in the former printing the communication at both stations at the same instant, thus affording the person communicating, the opportunity of perceiving whether he has transmitted the symbol correctly. It has the advantage also of secresy, for the apparatus at the distant stations may be locked up, and if any information be transmitted, it will be found printed when it is unlocked without the necessity of any attendant in waiting to watch its movements. The apparatus of the printing telegraph is worked altogether by the gravitating force of two large weights, electricity being employed merely as the agent for setting the apparatus in motion, and for stopping it at the points required. This is effected by the deflection of a permanent magnet,

which, as it turns, releases a revolving straight piece of wire that rests against a small notched cylinder attached to the magnet. The machinery continues revolving so long as the magnet is deflected, but when the electric circuit is broken, the magnet returns to its former position; the revolving piece of wire can then no longer pass through the notch in the cylinder, and its progress being thus arrested, the machinery is motionless.

When it stops, the arms of the small governor fixed to the upright revolving shaft collapse, and release a spring, which by striking against a small wheel thereon several projecting figures are fixed, one of these figures is forced against a piece of paper, and the letter opposite the paper is printed upon it. For the purpose of stopping the apparatus at the exact time that the figure required is opposite the paper, there is a dial with figures corresponding with those on the type-wheel; and when the hand of the dial, which turns round when the machinery is in motion, points to the figure, a small spring is pressed that completes the electric circuit, and the apparatus stops; and, on stopping, the figure is printed; a bell, or copper gong, is struck, and the paper is shifted to leave room for the next impression.

The lathe operations are admirably performed, and are effected without complication. The paper whereon the message is printed is fixed on a small cylinder covered with cloth, and as a type is withdrawn from the paper, the cylinder is moved slightly by means of a racket-wheel. The motion of the cylinder leaves a blank space for the impression of the next letter, and, as the cylinder turns on a spiral, the paper is elevated as it makes its gradual

evolutions: thus the figures or letters are printed on spiral lines. To make the impression of the figure visible on the paper, a ribbon saturated with dried printer's ink is interposed, against which the type presses, and leaves a very legible mark.

It is of consequence in such an apparatus that means should be provided for ascertaining that the two communicating telegraphs are printing correctly, or confusion would prevail. Mr. Bain has made an arrangement for this in the dial-plate, by introducing at one part a deviation from the other portions of the circle traversed by the hand, which enables the operator at each station to tell when the hands are passing over that part of the dial, and thus to know exactly whether the two correspond. One great advantage in employing the electric currents of the earth in working such a telegraph, independently of the saving of expense, is, the constancy of the power, by which means the current of electricity is always passing through the apparatus when it is at rest, and it is by breaking the current, that the telegraphic apparatus is set in motion. Should any accident occur to the wires, therefore, or to the generating plates, it is indicated directly by setting the machine in motion, and thus affording an opportunity of remedying the defect before the telegraph is required. The mode of working the telegraph by electricity generated by the earth itself, is, perhaps, the most important feature of the invention, as the principle is capable of extensive, valuable application for other purposes.

The small surface of metal required to excite sufficient electricity to work the telegraph is extraordinary; and a course of experiments to de-

termine the extent of metallic surface which would be requisite, have been instituted. Mr. Bain ascertained, that four square inches of copper and zinc would be sufficient to work the telegraph six miles. The current, it is true, was too feeble for practical purposes, and the surface of metal actually employed is one square foot at each station, from Nine Elms to Gosport. The extreme sensitiveness of the apparatus to the action of feeble currents of electricity is owing to an ingenious arrangement made by Mr. Bain, for augmenting the effect on the permanent magnet.

Mr. Highton has taken out a patent recently for improvements in the electric telegraph, which relates solely to the apparatus for communicating the shock at the one place, and to the apparatus for determining the nature of the shock at the other. His apparatus for transmitting the signal consists of three different parts; first, one of Armstrong's hydro-electric machines, and any of the other machines used for generating electricity; second, a Leyden jar, or a Leyden battery, or any other apparatus serving the same purpose, to which is attached an electrometer for the due regulation of the electric shocks; and thirdly, an instrument called a transmitter. This instrument consists of a wheel capable of moving in a horizontal plane round a vertical axis passing through its centre. This wheel carries three equal radii, or arms, branching out from its centre, and at equal distances from one another, so that the angle between any two is equal to 120°. The arms are constructed of some non-conducting material, and terminate in three metallic balls; these balls will be insulated from one another.

One of these balls has attached to it the wire which serves as a metallic communication between London and Exeter; the other two are connected together by a wire, which wire is also in communication with the earth. The wires must be so regulated as to allow the arms to revolve freely round with the wheel on which they are carried. On the circumference of the circle which these balls describe are placed two other balls, one in metallic communication with the electrometer, and the other in metallic communication with the outside coating of the Leyden jar, or battery. They are so placed that lines drawn from them to the axis of the wheel form an angle of 120°. Hence, contact can never take place without two of the first mentioned three communicating with these two. From this arrangement, it will be perceived that the operator, by causing the wheel to revolve, may transmit a shock of positive electricity from the electrometer to the distant terminus, or he may pass the shock into the earth, or lastly, he may transmit along the line a shock of negative electricity from the outside coating of the Leyden jar. It is easy to conceive that by attaching some primary conventional meaning to the number of the shocks, the nature of their electricity, and the order in which they follow one another, any signal may be communicated from the one end of the telegraph to the other.

Mr. Highton proposes several schemes to enable the operator at either terminus to decide on the nature of the shocks, and the order in which they are transmitted. One consists in causing a slip of thick paper folded double, or a slip of thin pasteboard, to move along at an uniform rate by

appropriate machinery, and two wires, one in connexion with London, and the other for completing the circuit, are brought near the paper, or pasteboard, and its opposite sides, in such a manner that a line joining the extremities of the two wires shall be perpendicular to the line of motion. The electric spark, in passing through the paper, makes a small black mark; when the electricity is negative the mark will be near the extremity of the one wire; when positive, near the extremity of the other wire. By this the electric shocks register themselves on the paper, which the operator can examine at his leisure, and thus determine the signal to be communicated. This is a very ingenious contrivance.

M. Dugardin, the inventor of the electric railway train indicator, and an electric telegraph, has promulgated a plan for rendering his invention valuable as a means of indicating the precise position of a train upon different lines. He proposes that as a locomotive passes certain places, or stations, it shall touch a spring in connexion with the wires, and be communicable with the index of the station by signs previously agreed on.

Nearly every railway company in the kingdom have adopted the electric telegraph, and are sensible of its usefulness in preventing accidents. Indeed, on single lines it is indispensable, and the directors of the London and Birmingham have constructed one for their branch to Peterborough, which is a single line. There is little doubt but the electric printing telegraph will become universal, not only in England, but on the railways of the new and old world.

The extraordinary velocity of the electric fluid

has been spoken of; and the fact of two gentlemen playing a game of chess by its agency illustrates its importance. One gentleman moved his men at Gosport, and the other at Nine Elms, and the contest was kept up with great spirit. The moves were communicated about every ten minutes, including the attention necessary to play accurately; and it terminated, after a struggle of ten hours, in a draw. The game was played by Mr. Staunton and Mr. Walker. The first gentleman is the best player in existence, and the victor of M. St. Amant, and Mr. Walker, almost equally distinguished as a scientific player, and was deeply interesting to the spectators present at both stations.

Electricity has been made useful in the manufacture of iron: and an ingenious Frenchman confidently states, that he has superseded gas-light by its power. It has also been converted into a motive power, by Beil of Frankfort-on-the-Maine, who has completed an electric magnetic carriage. The arrangement appears capable of immense power, and the machinery producing the motion with the battery, weighs a ton and a half. The carriage is mounted on ordinary railroad wheels. The battery consists of twenty plates of copper and of zinc. The arrangement has sufficient power to propel, with the greatest facility, carriages containing from thirty to forty persons.

We have, further, electricity employed in connection with thermography; also in the manufacture of lace. A gun has also been invented by Mr. Benningfield, which will discharge, by electricity, 1,000 to 1,200 balls per minute, and kill at a statute mile. Balls fired through three-inch

planks, became flattened like half-crowns. More bullets can be discharged by this electric gun than by two regiments of musketry. The barrels are placed on a small carriage, running on a pair of railroad wheels. The inventor has not yet disclosed the *modus operandi* of his contrivance; and few will wish his "killing process" to be carried into effect.

At Brussels, a new kind of electric telegraph has just been invented, by which the dispatch is written by a pen, by the action of the fluid: it is said to be eminently successful.

It is recently asserted, by scientific authority, that although Mr. Bain's printing telegraph is known to be successful, yet the action of atmospheric electricity upon the wire is likely to prove a serious difficulty in its operations. We must not omit to mention that Mr. Bain has constructed a beautiful clock, and the motive power is *electricity!* This splendid piece of mechanism is said to be eminently successful.

An electric telegraph was proposed from Dover to Calais; another to extend across the Atlantic! The latter scheme is thus propounded by an American in one of their periodicals:—Suppose a copper wire properly covered, and of sufficient size, say as large as a pipe-stem, and long enough to reach from Main or Nova Scotia to the coast of Ireland, were wound around reels, and arranged on board a steamer, so as to be reeled off as fast as the boat went, and dropped the whole width of the Atlantic, its gravity would sink it to the depth where water was so dense as to be of equal gravity, and of course beyond the reach of any collision. B[illegible]ning and ending on a bold shore, beyond

the reach of anchors, it would be out of the way of accidents, and exposed to but two kinds of obstruction, viz., from separation by its own weight, and the loss of the coating with which the metal must be protected.

The ocean currents and gulf stream would affect such an undertaking, by forcing the wire from its position. However, we give the project as an instance of the inventive powers of man. It would indeed be a grand desideratum to effect this rapid communication with our transatlantic brethren.

CHAPTER VII.

THE SCREW PROPELLER.

In a brief space of time this agent in propelling vessels has greatly progressed, even amongst those who, at first, resolutely opposed it as a chimera in science. It is now acknowledged to be a formidable rival to the paddle wheel, and bids fair, under the energy and talent of its inventor, Mr. F. P. Smith, to remove the ugly floats from steam boats.

The application of the screw appears to have been known to the Chinese for centuries. In this country the application has often been attempted, but nothing of any practical benefit had been achieved until Mr. Smith, of Hythe, in Kent, practically worked out the screw principle. There have been several imitations of the screw, which, for the most part, consisted of the employment of parts or segments, instead of a whole circle, and all these plans are inferior to the screw itself. By dispensing with a portion of the screw surface, they make the employment of a large diameter indispensable; while the outline of the screw being broken, instead of being a continuous sweep, has a considerable tendency to lay hold of weeds and any other substance in the way.

TRIALS BETWEEN THE SCREW AND THE FLOATS.

The fi trials that were made of the compara-
s of the screw and the paddle-wheel, when

the boat and engine power were the same, was in the steamer Bee, in June, 1842, at a measured mile in Long Reach, which showed the speed to be in favour of the paddle-wheel—paddle 7·723, 6·852. In this trial the boat was constructed for the paddle-wheels, and was not so well adapted for the screw, owing to the light draught of water; and in consequence of the engine being constructed purposely for driving paddles, a complication of gear-work was necessary to transmit the power from the paddle shaft to that of the propeller; and, although the lower boards of the wheel were unshipped when the screw was at work, neither the weight of the wheels, nor the resistance of the paddle-boxes, were removed from the boat. It was also a rough day, and the paddle-boxes being very large for the size of the boat, naturally caused a very considerable impediment, which would not have been the case had the boat been built expressly for the screw. The size of the Bee is thirty tons, and heavily constructed; the engine, of ten horse power, on the beam principle.

At Dover, the Archimedes, a screw boat, exhibited great superiority in point of speed, when the power and displacement of the other vessels were considered. Each of the Dover boats was fitted with engines by first-rate makers, all doing at the time the full number of strokes that they were rated at; whilst the engines of the Archimedes were making only about three-fourths of the number they ought, in order to have worked up to the power at which they had been estimated—*i.e.*, eighty horses.

The advantages of the screw over the paddle-wheels were great in a heavy sea, with the

Widgeon. A trial, also, took place between the Duchess of Lancaster and the Archimedes, at Liverpool The former had taken in four days fuel; whilst the latter had just arrived from her usual voyage. The Archimedes drew four feet more water than the Duchess, which enabled her to keep the eddy; while the Archimedes was compelled to keep the strength of the tide. The result of the race proved in favour of the Duchess, she being about two lengths ahead in a run of between three and four miles. These vessels are, as nearly as possible, of the same point of tonnage, but the cylinders of the Duchess are three inches in diameter larger than her rival.

In the Great Northern, the screw surface, as compared with her middle section, and total displacement of water, is as follows: middle section, at sixteen feet draught, upwards of five hundred and forty feet, whilst the screw contains little better than ninety feet, deducting the shaft; and with this small proportion, the vessel is moved by the screw through the water at the rate of nine and a half statute miles an hour, whilst the *slip* amounts to only one-tenth. The total weight, or displacement of the slips, at sixteen feet, is not less than from 1,300 to 1,400 tons. The singular result of the performance of the screw in propelling the vessel with little or no loss of slip, is somewhat curious; but it has been discovered that, when the superficial area of the screw, taken as a disc, bears about the proportion of one-fourth that of the immersed section of the vessel, her speed will be quite equal, if not a little superior, to that of the screw, supposing it be working in a solid, and advancing for each revolution its own length, or

pitch. The angle depends slightly upon the kind of vessel to be propelled, the sharp light boat requiring a coarser pitch screw, whose flange, or thread, at the circumference, stands at an angle of 60 to 68 deg. with that of the axis, will be found to give off the best effect in practice. It has been discovered that any increase in the number of revolutions produces a corresponding effect upon the speed of the ship, even from the lowest possible rate of the engine, up to the maximum rate.

The number of revolutions, then, of any particular sized screw, is only limited by the power employed. As regards the speed of the screw over that of the engine, a multiple of four to one may be taken as a general rule, with the ordinary condensing engine, going at 200 or 210 feet per minute. It is difficult to ascertain precisely in what way the water is acted on by the screw, when the vessel is moving rapidly through that element; but from close observation, with models in a glass trough, Mr. Smith has found that the water partakes but very little of the rotative motion of the screw, but is drawn on all sides from the circumference towards the centre, and, as soon as it gets within its influence, is immediately thrown aft in a column, not exactly parallel, but more in the form of an inverted cone, the apex of which is in proportion to the diameter of the screw; occasioned probably by the disposition bodies have to fly off from the object on which they impinge, at an angle equal to the angle of incidence. The screw, therefore, in its entire form, would produce this kind of action from the circumstance that, if right angles were

drawn from every part of it, a focus, similar to that alluded to, would be produced.

When the screw has been working, when the vessel is moved, the current of water which is thrown back, assumes the form of an inverted cone. A similar effect is produced when the vessel is in motion.

It may, therefore, be inferred, that the action of the screw, in the uncovered condition, is different to what it would be if the screw were enclosed, the supply of water would require to enter at the end of the screw instead of the sides, and flying off, it would pass directly aft in a column of the precise diameter of the tube. Mr. Smith has tried the effect of the tube, and finds the common principle the best.

The most extraordinary effect of the screw as a propeller, has yet to be discovered, viz., that with the proportions before named, it moves the vessel through the water as fast as if it were working in a solid. The cause of this anomaly, probably, is, that as the vessel passes through, the water closes in as fast as the vessel goes, to fill up the vacuous space that must otherwise be left; in doing this, the water apparently impinges upon the plunges of the screw, so as to oppose a greater resistance to its backward stroke, than if it were placed over the ship's side in a position similar to that of the paddle-wheel. This closing in of the water produces a current following the ship, but whether this current is chiefly due to the particular form of the vessel, or to the capillary attraction of its bottom, is a problem. When the vessel is moved, the engine always makes full two-thirds the number of strokes it makes when the vessel is under weigh;

and when under weigh, the boat almost invariably travels as fast through the water, as if the screw were working in a solid. Having stated that the water is thrown back two-thirds of the rate when at moorings, the remaining one-third may be imparted to the vessel when moving; so that, if the current be flowing only at the rate of six miles an hour, the effect of nine miles an hour may be produced upon the vessel, allowing the remaining two-thirds, or six miles, for actual slip.

Here, then, is a very important advantage over the paddle-wheel, and an advantage in placing the screw, or other propeller, in the dead wood, or run, of the vessel. The slip of the best paddle-wheel, even upon sharp-built boats, amounts to a *quarter*. It therefore follows that a similar result to that of the screw could only be obtained in the case of the paddle vessel being placed in a canal with two smaller channels, one on each side for paddles to work in. Suppose the speed required to be twelve miles an hour, and the slip to be a quarter, it would be necessary to drive the wheels at the rate of sixteen miles an hour; but in the event of the water in the two sides of the canal being, by some artificial means, put into motion at the rate of four miles per hour, in the direction of the vessel, her rate would then be equal to sixteen miles an hour. There can be no doubt that the following current is first set in motion at the expense of a certain loss of power, from whatever agent that power be derived. The effect of the application of the screw in the dead wood is to reconvert this power, which would otherwise be thrown away, to beneficial use. One great advantage of the screw, as applied to the dead wood

of the vessel, is the great facility it imparts to the operation of steering, owing to the rapid current of water past the rudder, due to the motion of the screw. The velocity of this current is never less than six miles an hour, as might be expected from the allegation that the engine moves fully two-thirds of its full rate, even when the vessel is stationary. The effect of the current of water on the rudder, causes the vessel, under all circumstances, to have steerage way, and makes the rudder sensitive, and very effective. But from the peculiar action, the fact of the propelling power being situated so far aft, would be highly disadvantageous in going head to wind, as the least yaw the vessel might make, would cause the wind to act on her side, and tend to turn her entirely round.

Some paddle-wheel steamers that have been lengthened by the bow, have been found to go much worse head to wind than before, simply because the elongation placed the shaft relatively too far aft; and paddle-wheels, or other propelling instruments, situated at the very stern, would, of course, be still more liable to this objection, if the effect were unredressed by some adequate provision. But the vast power the rudder possesses in a screw boat, even when the ship is brought up by the violence of the wind and sea, enables her to keep her head to wind better than any paddle-wheel vessel. The Archimedes has been found to go head to wind, when ordinary vessels of the same size and power are obliged to turn.

One of the greatest advantages of the screw consists in the uniformity of the resistance, as

compared to the paddle-wheel, in the consequent nice adaptation of the power of the engines to the exigencies of each particular case, which consequently becomes attainable. In the paddle-wheel boats on long voyages, great inconvenience arises from the unequal draft of water at the commencement and termination of the voyage.

At first the floats are so deeply immersed that the engines cannot reach their proper speed; while towards the end of the trip, the engines are disposed to run too fast, occasioning a great expenditure of steam without imparting a corresponding effect. In scudding, or making way through a heavy beam sea, the motion of the engines cause great irregularities, one or both of the paddle-wheels being sometimes quite out of the water. But with the screw, the resistance is always nearly the same, whatever be the condition of the wind or water. A greater average efficacy is thus attained than when the engines are working, sometimes above, and sometimes below, the most advantageous speed; and the engines are protected from the violent shocks and strains which flow from irregular movements. The applicability of the screw, as an auxiliary power to sailing-ships, is obvious; and there would be great advantages arising from abolishing paddle-boxes.

The introduction of the screw propeller as a substitute for paddle-wheels, has done much towards increasing the efficiency of war steamers, by the propelling apparatus being placed below the surface of the water, and, consequently, protected from the gun-shot of an enemy. But

something more is necessary to be done, in order to render a ship, fully equipped with steam machinery, capable of engaging with an enemy at close quarters, or even defending herself in a time of need.

HOW TO PROTECT VESSELS FROM THE DESTRUCTIVE EFFECTS OF CANNON SHOT.

We think that great protection to a ship's sides might be afforded by a series of steel springs, riveted to each other, on iron plates, and placed between the ribs and planking. These springs to be placed so that the weakest parts should rest on the strongest, and to be fitted so as to cover the boiler, and, of course, to correspond with the radius of the curve of the boiler, and to be bolted at the ends of the plates. Against these springs we would place a packing of horse hair and leather shavings, cemented together with a composition, and of sufficient thickness to render a vessel impervious to shot of any calibre. Over this stuffing we would place a steel lacing which could be secured by rivets or bolts. Thus when a shot struck the planking and penetrated beyond, it would meet with a substance which would cause it to rebound instead of entering the boiler; but should the shot be of sufficient weight to do mischief, then, in that case, it would carry away the boiler, lacing, stuffing and springs, with it, but never penetrate it. If, therefore, by this plan the boilers and gearing of the engines can be protected, a vessel, when otherwise disabled by the cutting away of her masts or rigging, could steam out of danger. The springs and coating substances might

be placed under the water line, and so high as not to cover the man-hole or other gear. The above plan has been suggested by Mr. R. John, an ingenious mechanic, and has been laid before the Lords of the Admiralty for their adoption. We will venture to assert that the plan will be rejected; yet still we think it would prove eminently successful, and ought to have a fair trial.

Steam engines, as arranged for paddle-fitted vessels, must of necessity be considerably above the water line, to give the required motion to the cranks, which usually work as high as the deck of the vessel, and in some cases, a little above it; and are, thereby, like the paddles themselves, likely to be entirely disabled by the first broadside they may be exposed to.

The screw requires that the machinery should be as low down in the vessel as possible; and several ingenious contrivances have been produced to effect this most important point in the equipment of man-of-war steamers. The plan of engine by Mr. F. P. Smith consists in a direct application of the power from the piston rods to the cranks, or screw shaft, by means of a triangular-shaped beam; which also, by a very simple kind of parallel motion, works the air pumps standing on each side of the cylinders, it occupies a small space in the length of the vessel; and although the cylinders stand in an upright position, the whole is considerably below the water line of the vessel.

Some plans have been devised, in which the working cylinders are, for the purpose of keeping them low down, placed on their sides. This is objectionable, on account of the probability that

the cylinders wearing more at the under side than any other part, by which, it is natural to suppose, the pistons would become worn also, and admit of the steam escaping between the upper portions of itself and cylinder.

The annexed diagrams show one form of the screw propeller.—A, the propeller; B, propeller

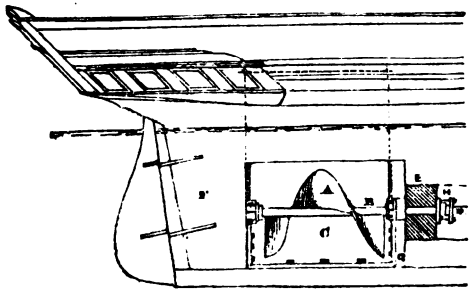


FIG. 1.

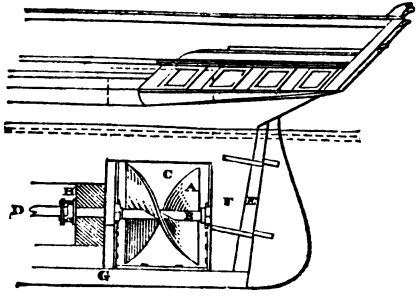


FIG. 2.

shaft; C, opening in the dead wood; D, a continuation of the shaft (B) in the engine, which passes through the stuffing box (H); E, stern post; F, dead wood of the vessel; G, an iron knee which carries the propeller; H, the stuffing box. Figure 1, is a side view of the single-threaded screw, or propeller, consisting of one entire turn. Figure 2, side view of the two-threaded screw, consisting of two half-turns placed opposite to each other on the shaft.

The chief disadvantage of the screw is the difficulty of bringing up the speed to the point indispensable to its proper operation. In those cases in which the screw is applied merely as an auxiliary power, short-stroke engines, working at a high velocity, and coupled directly to the axis of the screw, appear to be applicable enough. But in other cases, the intervention of cog-wheels, or belts, seem indispensable: and in a steam vessel such appliances are liable to objection. The best mode, at present in use, is driving the screw, when it is not at once connected with the engines, by the use of cog-wheels, very nicely fitted to each tooth, being divided into several pieces, in the direction of its length, the pieces being each advanced a little before the other in the manner of steps. By this expedient the friction and noise are diminished, and the chances of fracture in the teeth made less. Belts are a species of application exposed to the sea spray, and other circumstances, which makes them stretch and slip. The grand desideratum for the screw mode of propulsion is a rotary engine.

It has been doubted whether, although the

screw is an eligible mode of propulsion for slow and heavy boats, if it can be rendered available for vessels which are required to move at a great speed.

Ericson's propeller in the American vessel, "Princeton," is better adapted for large diameters than any other kind. The leviathan vessel, the Great Britain, is fitted with the screw. Since the first impression of this little work, this vessel has experienced a great misfortune on the coast of Ireland, which it is supposed will result in her total destruction. Whether any blame will attach to Captain Hosken time will show. We are inclined to the opinion that the charge of great carelessness is sufficiently obvious, and must be chargeable to some one. Government have constructed sixteen line-of-battle ships, and ten frigates. These ships are fitted with the screw, blockade vessels for our sea-ports.

The engraving represents the screw as at present adopted by the Lords of the Admiralty.

The success of the screw has made it of great interest to discover some method of translating the ordinary slow movement of a condensing engine into a velocity suitable to the screw propulsion. Cog-wheels, though now in use, are objectionable in steam vessels as a means of bringing up the speed, on account of the noise, tremor, and their liability to fracture in rough weather.

Lord John Russell and Sir Robert Peel screw boats, just built, of 40 horse power, have performed excellently. Their average speed has been eight knots an hour.

In calm weather, the screw can be used, and when there is plenty of wind the sails can be unfurled; thus enabling our steam vessels to carry sufficient fuel to reach the most distant shores.

Mr. Appsey, of Roupell-street, has invented a model of a screw to be worked by an air engine This model, a very beautiful one, consists of a screw $2\frac{1}{2}$ in. long, working in a 3 in. tube, which the inventor conceives will prove very effective, and working in tubing must increase the power of the pitch of the screw. Mr. Appsey is well known to possess considerable ingenuity and talent as an engineer, and we shall be glad to place on record, in our next impression, his success.

We are indebted to Mr. Beddoes, a very ingenious practical engineer, for the above description of Mr. Appsey's screw, who speaks in very high terms of the invention.

CHAPTER VIII.

STEAM—ITS PROPERTIES AND FORCE—AIR—ATMOSPHERIC PRESSURE—HEAT.

Dr. Lardner has so forcibly pointed out the properties of steam, that we cannot do better than quote a portion from his lecture, delivered on this subject. In order to understand anything distinctly about the steam engine, it is necessary that a clear knowledge should be attained of the phenomena attending the change of liquids into the gaseous state. All liquids are similarly affected; but, for the sake of convenience, let it be supposed that water, the most common of all liquids, is to be converted into the gaseous form. Let us suppose the bottom of a tube to be covered, an inch high, by a cubic inch of water, at the freezing point, and the atmosphere to be represented by an air-tight plug pressing on the water with a force of 15 lbs. Imagine a thermometer to be placed in the water, and a lamp applied to the tube; as the water gets heated the thermometer will rise, and continue rising until it reaches 212°. When this happens, the thermometer will stand still, and the plug will immediately begin to rise. The amount of the water at the bottom will then be sensibly diminished, notwithstanding there will be no appearance of liquid in the other parts of the tube. This will go on till, at length, there will appear to be no water at all in the tube, and the plug (if a tube of the required length could be

employed), would have risen 1,800 inches in the tube.

Supposing it takes one hour to raise the temperature of the water from the freezing to the boiling point, it will take five and a half hours to convert the boiling water into steam. Now, if the end of this tube be immersed in a vessel containing five and a half inches of water, at the freezing point, the plug will instantly fall down to its former position, the water will reappear and occupy its former position, and the five and a half inches of water in which the tube is immersed will be raised from the freezing to the boiling point. It will thus be seen that the water was in the tube, although unobserved; and that although the lamp only increased the temperature of the thermometer for one hour, it had continued imparting heat to the water in the tube for five and a half hours. The heat applied which does not affect the thermometer is employed in converting the water into steam, and in giving to it that mechanical effect which distinguishes steam from liquid water. As it takes one hour to raise water to the boiling point, that is, to a temperature equal to 180° of the thermometer; and as the water has the same capacity to receive, and the flame to impart heat, it necessarily follows that five and a half times 180° of heat is necessary to raise that water into steam; or in round numbers, 1,000 degrees of heat. By this, it would appear that the application of the lamp for six and a half hours would have raised the water to the temperature of the boiling point; so that it may easily be imagined what an expensive article steam is, when it requires such an extreme degree of

heat. A natural inquiry will present itself, whether the same circumstances would happen, if the plug were loaded with 30 lbs. instead of 15 lbs. In the main they would be the same. Upon the application of a lamp, the thermometer would rise, as before, to 212°. It would not, however, stop here, as in the former case, but continue rising, say to 230°, when it would remain stationary, and the moment it ceased rising, the plug would ascend in the tube, as before. The plug, as well as the thermometer, would be affected by the increased pressure; and instead of rising through 1,800 inches, would only rise 900, or a little more. If the load were increased, they might, in this manner, go on until the water would not swell in the tube so as to raise the plug, and the thermometer in the water would rise to 1,212°. This is the principle of what is termed high pressure steam. In all these cases there is one point of agreement: in all of them it takes the same time to convert the water into steam, whether the water expands into twice or 1,800 times its own bulk; and the same quantity of fuel to produce the steam.

In considering steam as a mechanical agent, it is natural to inquire, whether high pressure steam produces a greater or less effect with the same expenditure of fuel. The answer is, as far as we know, that it does produce a little more; because one inch of water, when loaded with 30 lbs., will produce a little more than half the quantity of steam which could be produced with a pressure of 15 lbs., the same quantity of fuel being required in either case. The force of steam may be easily manifested by placing a sealed Florence flask,

containing water, over a lamp, when an explosion will take place, and the flask be violently shattered into atoms.

The quality which steam possesses of suddenly condensing, when brought into contact with cold, is extremely important in the mechanical application of the steam engine, and admits of being shown in a very striking manner. If a bulb of glass, containing ether, be placed over a lamp, so that the ether may expand and fill the bulb, and also a long tube attached, it will be found that, upon immersing the end of the tube in water, and cooling the bulb, the water will rush up the tube, and fill the bulb.

The circumstances attending evaporation and condensation are interesting, from the many circumstances which connect them with the common occurrences of life. Few, perhaps, attend closely to the circumstances on which their comfort, perhaps their health depends. We all know, that if we expose ourselves in damp clothes we are liable to get cold; but we seldom reflect on the cause, and consequently are unable, under all circumstances, to guard against their effects. The process which produces cold is simply the process of evaporation. Evaporation is produced and accelerated by an extensive surface of damp and moisture being exposed to the air. The clothes, being spongy and porous, retain the dampness and moisture in their interstices, in a greater or less degree, and a chain of effects takes place from these circumstances. The clothing adheres to our backs when evaporation takes place, and, when a cubic inch of moisture is evaporated, the vapour takes away with it 1,000 degrees of heat, which must be supplied by our bodies. The skin

is of a spongy and porous nature, and full of extremely minute apertures, through which a liquid is continually proceeding, which arrives at the surface, and being carried off by evaporation, produces perspiration.

Leslie has invented a method of producing ice, by the employment of sulphuric acid. This acid has such a strong affinity for water, that if it is present in an atmosphere filled with vapour, it will immediately seize upon the vapour, and incorporate it with itself. He places water in a watch glass, under an air-pump, with sulphuric acid near it. The air being withdrawn from the pump, the sulphuric acid seizes upon the vapour as it rises from the water; and the water, parting with all its heat to maintain the vapour, is converted into ice. In performing this experiment, it is necessary that the vessel containing the sulphuric acid should not be in contact with the water, otherwise the degree of heat which accompanies the combination of the vapour and the sulphuric acid would prevent congelation taking place.

A very pretty experiment, to prove that the atmospheric pressure is a great agent in preventing water from boiling, can be performed with a flask half filled with boiling water, and closed at the neck. If it is in that state plunged into cold water, it will boil; but the ebullition will cease when plunged into boiling water. This is because the cold water condenses the steam in the upper part of the flask, and, by removing the pressure, allows the water to boil; whilst the hot water keeps up the temperature of the steam, which presses on the surface of the water, so as to prevent it from boiling.

From these investigations, it may be con-

cluded that a liquid or gaseous state is not essential to the nature of any substance, but that it is entirely dependant on the supply of heat which that substance has access to. We know that water can be passed through these three states, by the abstraction or the application of heat. Fluid mercury may be evaporated, and the fact ascertained by passing the vapour through a cold tube, when it will reassume a liquid state. It may also be made solid, so as to take shape, like a metal. The most rafractory substances we are acquainted with are capable of being converted into liquids by heat. All the metals we know of may be brought into a state of fusion, by a proper supply of heat. Indeed, all substances, by proper treatment, may be seen in the solid, fluid, and aeriform state. By turning the rays of the sun, through a lens, upon gold and platinum, we can decompose them, and convert them into gas. There is only one solid which has not yielded to fusion, and that is carbon, or the diamond; but we can only conceive that we cannot reduce it, because we cannot command a sufficient degree of heat to melt it, and maintain it in a liquid state. Of all liquids, there is only one which has not been congealed by the abstraction of heat, and that is alcohol, or spirits of wine.

We can only argue by analogy that the bodies which exist in the gaseous state can be reduced to liquids or solids; but we have reason to suppose that the substances known as atmospheric air, oxygen, hydrogen, etc., are, in fact, nothing but the steam of various substances which cannot exist in the liquid state upon the surface of our globe, without being deprived of a large portion

of heat. This analogy has been confirmed by recent experiments and discoveries, particularly by those of the distinguished Farraday. Neither steam nor any gas can be reduced to a liquid by compression alone, however high the degree of compression applied to it, notwithstanding the assertions of superficial writers, and even of some who are otherwise well informed on the subject. But if, by the compression, we could squeeze out the heat from these gaseous bodies, we could then liquefy them. Dr. Farraday has substantiated this, by actually converting several gases into liquids. For instance, he found that when carbonic acid gas was submitted to a pressure of 1,000 lbs. on the square inch, it became a liquid. It must, however, be remarked, that as the pressure is increased, the temperature is raised; and it is not until the gas is cooled that liquid is produced.

Prodigious mechanical power has been obtained, by the mere ability, on our part, to convert a liquid or water into steam, and re-convert that steam into water. In order to convert water in vapour, we apply heat. The least promising liquid is that which requires the largest application of heat; and, of all liquids, water consumes the largest quantity of heat, requiring 1,000° to raise it from a boiling state to a state of vapour: therefore, *à priori*, a philosopher would say, try spirits of wine, or a thousand other things, but do not try water, for this special reason. A vessel impelled by a steam power of 200 horses, consumes one ton of coals per hour, or twenty-five tons per day; therefore, to provide for a voyage of twelve days, it would have to carry with it twelve times

twenty-five tons of coal. It is generally understood, that a vessel cannot carry more fuel than is necessary for the purpose of propelling it ten or eleven days.

In considering the prospects of improvement in these respects, we naturally look towards those liquids which are most readily turned into a gaseous form. Ether and alcohol are easily converted into vapour; but in the way in which the steam power has been applied, these liquids are expensive. If it were used in a high pressure engine, the vapour would escape into the air, and be lost; whilst, in a condensing engine, although not lost, it would be mixed with so much water that its separation would be attended with considerable expense. There is only one other way in which it is possible to use alcohol, namely, by condensation, in contact with a cold surface. If we introduce the vapour of spirits of wine into a thin shell, formed by two bodies placed one upon another, after working the engine, it will spread over the cold surface of the hollow shell, the steam will be re-converted into a liquid state, and trickle out at the bottom, so as to be warmed over again: this might be carried on from time to time.

But this great step must be followed by another improvement in the steam engine, especially for the purposes of transport, both by land and by water, which will doubtless be cultivated in our own time. It is the application of the gases, and especially of carbonic acid gas, in a liquid form. If we could obtain carbonic acid in sufficient quantity, and on sufficiently moderate terms, there is no reason why it should not be employed to supersede steam at the present time. This gas takes

the liquid form at the common temperature, under a pressure of 1,000 lbs., and in that state exerts a prodigious power, and, from its small bulk, would effect a saving of tonnage. The difficulty to its adoption lies in the price of the liquid, the providing of proper air-tight valves and pistons, and in guarding against the corrosion which the carbonic acid would cause in the materials themselves. We may, therefore, look forward to the superseding of coals altogether in the steam engine, by the use of the liquid carbonic acid, as nothing would be necessary except to send it into the receiver, and let the piston of the engine work as with steam; possibly it might be found expedient to apply heat; but a trifling degree only could be applied, as the power of the gas is so great, that it has no limits.

POWER OF STEAM.

HORSE POWER has been defined to mean many powers; but the commonly received doctrine is that promulgated by Messrs. Boulton and Watt: viz. 33,000 avoirdupois pounds weight, raised one foot high in a minute. The medium power of a horse is a about equal to 22,000 pounds raised one foot high in a minute: but the former is taken as a standard. Now, an engine will work unceasingly for twenty-four hours; while a horse works only at the rate of eight hours: hence the engine works three times as long as one horse. The power of a man may be estimated at one-fifth of the real power of a horse (22,000), or 4,400 pounds raised one foot per minute.

Tredgold's table will give some idea of the

power procured from steam in the double-acting steam-engine by Watt.

Let the force of the steam in the boiler be		1·000
The following deductions must be made :—		
Force impelling the steam into the cylinder.....	.007	
Cooling in the cylinder.....	.015	
Friction of piston, and loss.....	·125	
Force impelling the steam through the passages.....	·007	
Force to work valves, raise injection water, and overcome friction of axis.....	·063	
Loss from steam cut off before end of stroke	·100	
Force required to work the air-pump	·050	
	·368	·368
		632

Thus, about 4-10ths are lost from friction, working of the pumps, etc. The pressure in the boiler may generally be estimated at that of a column of thirty-five inches of mercury. The steam in the boiler is always kept a little stronger than the air—2½ to 4 lbs. on the square inch, or about five inches column of mercury.

If this be multiplied by ·632, the proportion of the above force which remains after making the necessary deductions, as per the above table, it gives 22·12 inches, as the force of the steam on the piston represented in inches of a column of mercury: *i.e.* 10·83 pounds to the square inch. But the uncondensed vapour in the cylinder resists this force; it also must be deducted from the above. If the temperature in the condenser be 120°, this vapour will have a force of about 3·7 inches of mercury, or, 1·31 lbs. to the square inch: 3·7 inches deducted from 22·12 inches, gives 18·42 inches of mercury—or, 1·81 lbs. deducted from 10·83 lbs. gives 9·02 lbs. per square inch, as the effective pressure on the piston. Calculated in

circular inches, as is sometimes done, we have 7.1 lbs. to the inch.

The following extract from the author above quoted, will show the method of computing the power of an engine, the above data being assumed.

"RULE.—Multiply the mean effective pressure on the piston, by the square of its diameter in inches, and that product by the velocity, in feet per minute; the result will be, the effective power in pounds raised one foot high per minute.

"To find the horses' power, divide the result by 33,000. Example.—The diameter of a cylinder of a double engine being twenty-four inches, the length of the stroke five feet. (A *stroke* means a motion of the piston, from the top of the cylinder to the bottom, and back again. When the *length* of a stroke is spoken of, only half the stroke is meant. Thus, if the length of stroke be five feet, the stroke will be ten feet.) The number of strokes per minute, twenty-one and a-half, and the force of the steam in the boiler, thirty-five inches of mercury, or five inches above the pressure of the atmosphere—required, its power.

"The velocity is $2 \times 5 \times 21\frac{1}{2} = 215$ feet per minute, and the mean effective pressure on the piston will be 7·1 lbs. per circular inch; therefore, $7{\cdot}1 \times 24^2$ (the square of the piston's diameter, or 576) $\times$ $215 = 879{,}264$ lbs. raised one foot high per minute; or, $\frac{879{,}264}{33{,}000} = 26{\cdot}64$ horses power. The nominal power of this engine would be only twenty horses' power, by Boulton and Watt's mode of calculation; but it will be found that the nominal and real power nearly agree, when the steam acts expansively." Such an engine would require, for steam, half a cubic foot of water per minute, or, thirty cubic

feet hourly; or, dividing 246·6 by 26·64, 9·2 lbs. of coal per hour for each horse power. It is said by some that the fuel consumed is about one half more than this—fourteen or fifteen lbs. per horse power hourly; this is the more general estimate.

In an engine working expansively, the steam being cut off at about one-half ($\frac{1}{2 \cdot 1}$) of the stroke, the mean force would be 4·8 lbs. on circular inch. This multiplied as above, would give 594,432 lbs. raised one foot per minute, or, dividing by 33,000, eighteen horses' power. The fuel required would be about one-half ($\frac{1}{2 \cdot 1}$), 117 lbs. per hour, or, 6·5 lbs per horse power, hourly; about 2·7 lbs. per horse power being saved every hour.

In a double-acting engine, of about twenty horse power, the diameter of the piston is about twenty-four inches, its area being 452 square inches, or 22·6 inches, for each horse power. The effective pressure on the piston may be about 7·3 lbs. per square inch. The length of stroke will be five feet, it will make twenty strokes per minute, and its velocity be 200 feet per minute. Such an engine would raise 660,000 lbs. one foot high per minute; and consume hourly 166 lbs. of coals, or 8·3 lbs. per horse power. In smaller engines, the pressure on the piston is less, and the consumption of fuel greater. In large engines, the reverse. In an engine of 200 horse power, the effective pressure on the piston may be about 8·9 lbs. per square inch, and the coal consumed hourly is, per horse power, only 5·5 lbs. Mr. Tredgold estimates the deductions to be made from the force of the steam in the boiler, in high-

pressure engines, at about 0·4, the whole force being 1·0. The effective pressure thus is 0·6.

By the construction of boilers of marine engines, they consume less fuel than land engines, some say in the proportion of two to three. The following table shows the relative heating powers of the chief sorts of fuel in use for steam engines:—

Kind of Fuel.	Pounds of water converted into steam of 222° (from 52) by one pound of fuel.	Pounds of fuel required to form a cubic foot of water into steam.
Caking coal.....	8·4 lbs.	7·45 lbs.
Splint coal	6·75	9·25
Coke	7·7	8·1
Dry pine	3·1	20·02
Dry oak	5·13	12·2
Dry compact peat	3·35	18·7
Charred peat	4·85	12·9
Culm (Glasgow)	2·85	22·0
Culm (Welsh) ..	3·56	17·5

In estimating the quantity in practice, Mr. Tredgold, from whom the above table is taken, adds 1-10th (10 per cent.); thus making 8·22lbs. of caking coal the quantity necessary to vaporize a cubic foot of water, which weighs 62 lbs. avoirdupois. Equal heating power is obtained from 1 lb. of Newcastle coal, 1½ of Glasgow coal, 3 of wood, and about twice as much culm as coal.

POWER OF STEAM.

The force of steam may be ascertained by very simple experiments. If you put a small quantity of water into a tea-kettle, and place it over a fire, it will disappear in a short time, having escaped by evaporation. But if its escape be prevented by stopping the spout and crevices air-tight, it will burst the kettle into a thousand pieces, and not a vestige of fluid will you discover; whereas should

you inject suddenly a jet of cold water into the kettle, the steam will be immediately condensed into water again. If the steam of boiling water be at liberty, the water never attains more than a certain degree of heat, but if confined in a closed vessel, the additional fire not escaping, the power of steam is increased, it reacts on the water, and raises the heat so much higher, that it would keep lead in a melting state, and so penetrating, that it would soften the marrow-bone of an ox in a few moments. By Papin's Digester the above facts may be ascertained. This instrument is a strong vessel made of copper, fitted with a thick close cover, and fastened down by several strong screws, so as to render it steam-tight in great degrees of heat. To render it safe while being used, there is a valve in the cover to let out the steam when it is too violent; this valve is kept down by a steel-yard, with a weight moveable on it, to regulate the degree of steam.

Papin, on one occasion, having fixed things right, and put a pint of porter in his digester, with two ounces of marrow-bone, placed the vessel horizontally between the bars of the grate, about half way into the fire. In three minutes he found its temperature raised to a great height, and perceiving the heat to become more intense, he stepped to a side table for an iron to take the digester out of the fire, when it suddenly burst with a loud explosion. It was heard at a considerable distance. The bottom of the vessel that was in the fire gave way; the blast of the expanded water blew all the coals out of the fire into the room; the remainder of the vessel flew across the room, and striking the leaf of an oak table an inch thick,

broke it all in pieces, and rebounded the length of the room back again. He of course could not perceive any water, the fire was quite extinguished, and every coal was black in an instant.

A serious accident occurred at Chelsea, showing the enormous force of steam. A steam engine was being repaired, and as the workmen were endeavouring to discover the defect, the boiler exploded, and a cloud of steam rushed out of the fracture, struck one of the men, and killed him in an instant; and on taking his clothes off, his flesh separated from his bones.

THE PROPERTIES OF GASES AND AIR.

AIR is that thin, invisible fluid surrounding the earth, and extending some miles above its surface, in which all earthly bodies are immersed. Common, or atmospheric air, is composed of several substances, differing widely from each other in their natures and their effects upon animate and inanimate bodies. The two principal constituents of the atmosphere are oxygen and nitrogen, existing in the proportion of 21 of the former, to 79 of the latter. Mr. Griffith gives it as one volume of oxygen, to four of nitrogen. Air also contains water in solution, and other substances.

The properties of atmospheric air are transparency, compressibility, and elasticity. It is void of taste and smell, respirable, and capable of supporting flame. Its component parts are chemically combined; its specific gravity is ,00123, or thirteen times lighter than water. It is constantly entering into combination with other substances; and its waste is supplied by the changes which are going on principally by the action of caloric

upon other bodies, in Nature's great and glorious laboratory.

OXYGEN is the principal constituent upon which most of the chemical properties of the atmosphere depend. Its tendency to combination is so strong, that it is impracticable to obtain it in an entire state. When combined with caloric, it is in its most simple form. It is permanently elastic, compressible, transparent, inodorous, and tasteless. Combustion is much more rapid in pure oxygen gas, than in common atmospheric air. The greater the quantity that comes in contact with ignited bodies in a given time, the more violent the combustion will be, and this is the reason why bellows are resorted to by smiths. Iron, and all metals, burn with a very vivid and brilliant flame in pure oxygen. Animals live longer in a given quantity of oxygen, than in the same quantity of atmospheric air. It facilitates germination, and is a constituent principle in water, in all the acids, the metallic oxides, and almost all animal and vegetable substances. Its specific gravity is a little greater than common air. Oxygen is a supporter of combustion, and can be mechanically mingled with nitrogen in the same proportions as it exists in the atmosphere.

NITROGEN GAS constitutes $\frac{79}{100}$ of the atmosphere. Its greatest use is to dilute it. Like oxygen, it is compressible, permanently elastic, and tasteless. Its specific gravity is ·00115. Nitrogen is not capable of supporting either respiration or combustion.

HYDROGEN GAS is considered to be the upper

strata of the atmosphere. It is permanently elastic and compressible. Its specific gravity is ·000094; being thirteen times lighter than common air, and the lightest of all known substances. It is highly inflammable. Hydrogen gas is used in filling balloons. It has been tried in France and America for lighting towns, and with success.

Carbonic Acid Gas is the most highly diffused of any in nature, being found, in a small proportion, in the atmosphere. It exists in combination in all kinds of vegetables, in considerable quantity; and likewise, in small quantities, in all kinds of animals. Caverns and wells sometimes contain it. This gas is the true respirable material for vegetables.

Air, not being perceptible to the organs of vision, is but little understood. Its power is very great: the waves of the ocean are elevated to an enormous height, forests prostrated, and the most stately edifices crushed to atoms by its force. It is one of the most powerful and useful, yet the most destructive agents in nature. The whole body of air that surrounds the earth is denominated the atmosphere; the height is judged to be about sixty miles. Its mean state is supposed to be 850 times lighter than water. From its being elastic, and subject to compression, it is heaviest near the earth, and lighter and less dense the farther you ascend into the atmosphere. The amount of its force has been estimated with great nicety.

Force of the Atmosphere.—Take a stout

glass, or tube, closed at one extremity, and about thirty-two inches long, and fill it with quicksilver, leaving the open extremity closed by the thumb, or cork, or any flat plate, so as to prevent the quicksilver escaping; then invert it, placing the open end under the surface of the quicksilver in a vessel containing a quantity of this liquid. Now withdraw the substance, closing the lower end of the tube, and immediately the quicksilver will descend in the tube, leaving a vacant space at the spot, and will soon become settled at a point about thirty inches above the surface of the quicksilver in the lower vessel. The quicksilver in the tube, contrary to the usual action of gravitation, in causing fluids communicating freely to come to the same level, remains considerably elevated above that in the lower vessel.

There must be some force, then, supporting it in that elevated situation, and that power is the pressure of the air, which is pressing with great force on the surface of the quicksilver up into the tube. There is nothing in the upper part of the tube pressing the quicksilver down; but the column of quicksilver, by its weight or force of gravity, is pressing downwards upon the quicksilver in the lower vessel, resisting the atmospheric pressure, and tending to descend into the tube, and come to a level with the quicksilver below. As the atmospheric pressure and gravity of the quicksilver are the only forces acting, they must be equally balanced, or in equilibrium, when the quicksilver has become stationary in the tube, which takes place when the column is about thirty inches high. We thus ascertain that the column of air reaches from the surface of the earth to the extreme limits of the at sphere.

If we suppose the horizontal section of the orifice of the tube to be equal to a square inch, the column of quicksilver would weigh fifteen pounds avoirdupois. The pressure of the air which balances the quicksilver must be the same in amount; and as the pressure which is transmitted to the orifice of the tube is that of a column of air, the same in section, a column of air a square inch in section, must weigh fifteen pounds, and the atmosphere must press with that force on every square inch of surface, or every square inch is as much pressed by the air as if, supposing there were no air, a weight of fifteen pounds rested upon it. The degree of pressure to which any surface is exposed from a gaseous body, is always spoken of by stating the amount of pressure on the square inch. A force double that of the air is thirty pounds per square inch, half that of the air, 7·35 pounds per square inch.

The term atmosphere is sometimes employed to denote degrees of pressure, as a pressure of two atmospheres, meaning a pressure double that of the air; three atmospheres; ten atmospheres; an atmosphere and a half, and so on. To ascertain the total amount of pressure exerted by a gas on any body, *find the number of square inches in the surface on which the gas acts*, and multiply this number by the pressure on each square inch. To find the number of square inches in a circular area, multiply the square of the diameter by ·7854; or half the circumference by half the diameter. The area of a circle is a little more than three-fourths, and a little less than four-fifths, of the square of the diameter.

The common barometer is used to indicate

variations in the pressure of the air. These variations, however, are within small limits, the mercury in this country seldom rising higher than 30·8 inches, or falling lower than 28·1 inches. Its mean height, at the level of the sea, is 29·82 inches. The space between the upper surface of the mercury and the top of the tube is called a *vacuum*, or void; meaning thereby an empty space, or, at least, space containing none of the material bodies with which we are at present acquainted. A vacuum procured in this manner, is called the *Torricellian vacuum*. As water is a much lighter fluid than quicksilver, it is supported in a tube much higher than the latter fluid. A column of water 33·87 feet high, is required to counterbalance the pressure of the air, and render the liquid stationary in the tube.

If, in the tubes filled with water to the height of 33·87 feet, or mercury for thirty inches, an opening be made at the top, so that the air is admitted to press upon the upper surface of the liquid, as the pressure of the air communicated from outside the tube, and which supported the liquid in that elevated position, is now *balanced* by the atmospheric pressure acting *directly* upon the liquid in the tube, and pressing it in an opposite direction, the liquid will obey the law of gravitation, and descend till it come to the same level without and within the tube.

A few illustrations of the power and action of the atmospheric pressure may be here adduced. A sucker, or moistened leather, with string, with which boys raise stones, depends on atmospheric pressure, which forces the leather to the stone with a pressure of fifteen pounds on the square

inch. When the nozzle and valve hole of a pair of bellows are closed, it requires force to separate the sides, as the atmosphere presses them together. Could air be perfectly extracted from houses, or buildings, they would be crushed and split into pieces directly. If you withdraw the air from a case bottle with an air-pump, it will be pressed into a thousand pieces, accompanied by a report as loud as that given by a pistol. The pressure of water by air causes it to ascend in a pump, when the piston is raised. Many principles in natural philosophy, also, may be explained by the pressure of the atmosphere, as well as many things that are now applied to instruments and propelling machinery. Torricelli discovered the pressure of the atmosphpre in 1643. This philosopher also invented the barometer. A few years later, in 1650, Gueriche, of Magdeburg, invented the air-pump.

We cannot take advantage of air as a moving power until we have procured a *vacuum;* and when this is effected, the air will rush in with great force, and push anything of less resistance before it. If we place a thin plate of glass, or a piece of bladder, air-tight, on the top of a glass cylinder open at both ends, and set the cylinder on the plate of an air-pump with the closed end uppermost, the air, though pressing the glass plate downwards with a force of fifteen pounds on every square inch of its surface, will nevertheless cause no motion or change, as the air in the interior resists and balances this pressure by its elasticity; but if, by working the air-pump, the air be withdrawn from the interior of the cylinder, the exterior air will then crush the glass plate, and rush with great

force into the interior of the cylinder; or had there been in the place of the piece of flat glass a piston, fitting air-tight to the sides of the cylinder, the atmospheric pressure would have forced it gradually down, as the air was withdrawn from the interior. Here, then, is a source of motion, when the air is abstracted from the tube or cylinder. This is the only difficulty in atmospheric pressure being applied to propel locomotives on railroads. It is well known that a perfect vacuum cannot be made; but if, by stationary engines, the air can be exhausted with sufficient rapidity, then there is every probability of their succeeding. The experiment has been tried in France, in Ireland, and in England with success.

CALORIC, OR HEAT.

CALORIC means heat in whatever form it may exist. It is applied to its sensible, and its latent form. By its sensible form is meant that which is perceptible to the senses, producing warmth and heat. By its latent form is understood its combination with other substances, with earth, water, air, and every other substance in nature. The difference of signification between heat and caloric is, that heat is used to express a sensible form; and caloric, both its sensible and latent form, in which it is known to exist. To determine with exactness the greater or less degree of heat, or caloric, in its sensible form, which exists in any place, thermometers are made use of. The different degrees of heat and cold existing at different times, and in different places, is called *temperature*. Thus we speak of the temperature of the human body, of heated

iron, boiling water, etc. The temperature of boiling water is 212 degrees of Fahrenheit's scale. The temperature of the human body, in a state of health, is about 80°; in fever, 212°. Lead melts at 540°; ether boils at 98°; copper melts at 4·587°; iron at 2·637°.

Caloric exists everywhere, and in every thing. Water, and even elastic vapours and air, reciprocally, in proportion to the quantity possessed by them. This may be better understood by considering that caloric is composed of particles perfectly separate from each other, every one of which passes from some body in every direction. These directions are as various as it is possible to conceive, and there are rays of lines of them passing with immense velocity in every imaginable course. All bodies are greatly changed by the application of caloric; solid bodies are converted into fluid, and fluid into aeriform. The natural state of all bodies is solid, as the natural state of water is ice. If caloric were totally abstracted, every thing in nature would be congealed.

It has been stated that there are some exceptions to the expansive quality of heat. The only real exception, as clay is not properly an exception, is in regard to water. Water expands both ways from 40 degrees of Fahrenheit's thermometer. The increase of cold below 40° produces *expansion*. Some very important and curious phenomena may be explained on this principle, relative to heat, or the absence of it. This is what occasions the breaking of small earthen, iron, and wooden vessels, in which water has been left, during a severe night in winter. This what causes the sharp, cracking sounds in , when there has been a

change from warm weather to cold. It is this which causes ice to expand and burst, the subsequent jarring, crashing, and rumbling, and those vast fissures upon lakes, and other bodies of water, when they have been frozen.

Water freezes at 32^0; oils at 36^0. That quantity of heat required to melt any substance, is called its caloric of fluidity

Caloric tends to an equilibrium—that is, to exist in one place and in one substance, as much as in another, until all are heated to a like degree. All bodies have an attraction for it, until all are equally heated, and then the particles repel each other. From these two principles, the tendency of bodies to attract caloric, and of its particles to repel each other, the equilibrium is constantly kept up. All bodies have not an equal attraction; that is, some do not attract it so speedily as others. Glass has less attraction for it than lead, lead less than iron, iron less than brass, and brass less than silver. Those bodies which attract it the least, retain it the longest. Mercury retains heat but a very little while, consequently, a person immersed in mercury would freeze quicker than in any other situation.

Caloric is reflected and radiated; when a body reflects it, it does not part with its own, but with that it receives from another. When it radiates, it not only proceeds from, but originates in the body itself. It is radiated, when it passes from one body to another, when it is dispensing itself, and progressing towards an equilibrium. All bodies radiate it; not only those which are of a higher, but those which are of a lower temperature. Caloric, also, has the power of producing certain

effects on bodies. When any substance possesses this power in equal degree, as red hot iron, it is said to be at a high temperature, and at a low temperature when cold; and the terms rise and fall are used in the same sense.

The most general effect of caloric is expansion. This is almost universal. Its operation is like little wedges, cleaving asunder, or propelling to a greater distance from each other the particles of which every substance is composed. Mercury, iron, stone, water in its liquid state, elastic vapours and air, and everything else in nature, with one or two exceptions, are expanded and enlarged in proportion to the degree of heat which is applied to them. That is, the same degree of heat, when applied to the same substance, will always produce the same degree of expansion; but solid substances differ from each other in this respect, and liquid substances expand more than solid, and aeriform more than liquid. All elastic fluids whatever undergo an equal expansion from the same degree of heat.

THE THERMOMETER.

THERMOMETERS operate and decide upon the presence of heat upon the principles of expansion. Mercury, the principal thing made use of for the construction of thermometers, rises in the glass tube in proportion to the heat which is applied. Different thermometers are made use of for different purposes, and by different nations for the same purpose. Spirits of wine is made use of for low temperatures, and a composition of clay for furnaces, and very high temperatures. To decide

upon the temperature of the weather, and moderate heat of any kind, Fahrenheit's thermometer is made use of in England and America, and Reaumur's in France. Fahrenheit's is generally divided into 212 degrees above zero, and 40 below; and Reaumur's 80° above zero. In the former 32° corresponds with the freezing point, and 212° with the boiling point; in the latter, 0° is the freezing point, and 80° the boiling point. Wedgewood's thermometer, sometimes called a pyrometer, is composed of a clayey substance, which, instead of expanding in proportion to the heat applied, contracts, and therefore is a seeming exception to the expansive quality of heat. It is not an exception, however; for clay being of a spongy nature, or full of pores or interstices, these, by beginning fusion, are more or less obliterated, and, of course, the clay consolidated, in proportion to the heat which is applied; and this is the cause of the contraction.

Increase of temperature is a sensible effect of caloric, from whatever cause it proceeds: from collecting the sun's rays, by the concave mirror, and double convex lens; by electricity, by friction, percussion, collision, by condensation, and by combustion. Those surfaces which are bright and highly polished, as tin, plate, polished gold, brass, or silver, radiate heat slowly, and hence they retain their heat a great while; while those surfaces which radiate heat fastest, absorb the greatest quantities of radiated heat; those that radiate slowest throw off (reflect) the greatest part of radiated heat that falls from them. Heat entering into fluid causes it to become larger, and, of course, lighter; and the cold and heavier particles

above necessarily descend, and push the warm particles upwards: thus the whole of the fluid is quickly heated, not by the transmission of heat from particle to particle, as solids, but by the successive application of every part of it directly to the source of the heat. Whenever a fluid is heated, currents ensue; hence the wind, the removal of the warm and foul air expired from the lungs of animals, and the supply of fresh air to support life; hence the removal of noxious air formed by burning bodies, and the supply of pure air to keep up the combustion; hence ventilation, which consists in ensuring a rapid current, by a strong fire with a tall chimney.

Thus, when heat enters a body, it becomes larger. It penetrates through its entire substance, and repelling its particles from each other, their distances are increased; this is called expansion. When heat leaves a body, its particles approach to each other, and its bulk is diminished; this is termed contraction. When solids are sufficiently heated, they melt, or become liquid; this process is termed liquifaction. When liquids are heated to a great degree, they become gaseous, like steam, or air; this is termed vaporation. It is simply a very great degree of expansion, but attended by a change in form. Liquids become solid again (congeal); and vapours turn liquid (condense); and they are cooled sufficiently. Heat appears to be the elastic power which aerial bodies possess at all temperatures, high and low.

Thus the cylinder of a steam engine should be brightly polished, that it may not lose heat by radiation. Tubes containing steam, water, or h ed air, for warming rooms, should be rough,

dark, and porous in the apartment where it is intended that they should give out their heat, but bright and polished before they reach that place. When iron is placed in a fire, the end out of the fire soon becomes warm; this is by the transmission of heat. In the same way in which heat travels along the particles of the same body, it can pass between two bodies in contact; the transmission of heat in this way is called conduction. The powers of bodies in conducting heat appear nearly in proportion to their densities.

Fur, straw, cotton, silk, wool, are slow conductors. Bad conductors take a long time to become heated, but lose their heat slowly; hence they are useful for confining heat, or excluding it. Good conductors get quickly heated, and cool as rapidly.

All gases and vapours expand equally through the same range of temperature. Bars, rods, and wires elongate by heat. Every gas or vapour contains within itself a source of expansion, and hence of moving power, which is prevented from acting and producing motion; but some other force compresses the gas, and thus resists its action. Particles are constantly pressing outwards on each other, and upon bodies around them; and the gas is continually endeavouring to swell out in all directions, and occupy a larger space; this power of gaseous bodies is termed their elasticity, elastic force, or elastic power.

FIAT JUSTITIA.

PREVIOUSLY to closing this little manual, we wish to express our opinions relative to the conduct and management of the several railways proceeding from London and its environs to different parts of the country, and we are certain that we shall strictly adhere to our motto. It is to be regretted that such marked distinction should be afforded by officers of the several lines to persons who have an outward appearance of wealth and goodly luggage, their politeness is extreme, the very scent of gold is, to these supercilious underlings, so sweet, that they will crawl and crouch to oblige, because a first class passenger may be a director, and any incivility exhibited to such a nabob would assuredly be visited by dismissal. A second class passenger is waited on with a diminished degree of regard, but he is attended to with avidity. But a third class poor devil is left to shift for himself, and if he can get his luggage, perhaps merchandise, or tools, or clothes, placed anywhere, in all probability the rain or snow will penetrate them and spoil half.

We will speak of the London and Croydon, London and Dover, and South Coast Railway (London Bridge). We will admit that the Croydon Line at almost every station the policemen are extremely civil and polite; we wish we could write the same of the petty clerks at the London Terminus, whose insulting conduct to the third class passengers cannot be too severely reprobated.

If the Eastern Counties Railway have their monarch in Hudson, so have the London and Brighton or South Coast Railway, to which must be added the Croydon Line, a king as potent—a black magician, who, for the paltry sum of £1,200 a year, is pledged to save the parsimonious monopolists £10,000 per annum. This clever person delights in the name of Peter Clark. He has commenced his reign as great men and profound financiers generally do, not by cutting down his own salary, but by inconveniencing that portion of the public who are *third* class passengers, and by reducing the wages of the labourers and other officers. Until this sovereign commenced his reign the third class passengers were permitted to pay their money in the office of the London termini, and could seat themselves if they desired while waiting the "pelting of the pitiless storm," but now it is a fact, that the third class passengers are compelled to pay their hard-earned cash in a *stone passage* with folding doors at each end, and as the supercilious clerks will open the hole cut through the wall of this same passage into a box erected in the front office when they think proper, the passengers are left between two doors with the atmosphere rushing through the cold stone passage with a violence which causes *many* to prefer standing outside,—excluded like fallen angels from the comfort they enjoyed a few short weeks before. The box constructed in the office receives the first and second class fees.

Instead of the legislature fixing the rates of the poor abused third class passengers at one penny per mile, they should have made it half that sum.

We predict that the day is not far distant when these leviathan monopolists will be made to furnish not only a cheaper transit, but also those accommodations which befit human creatures, and not huddle them together similar to beasts, as is the case on the Greenwich and Blackwall lines.

One word at parting with Peter Clark. This person has reduced the wages of the poor labourers on the lines 6d. per day, and the wages of the policemen 2s. per week; he has also discharged two of the oldest servants of the line, Childs, of Forest Hill Station, and Banister of the Annerley Station, two men, one an old tar who has served his country in many a tough fight in various climes, and the other some years since preserved the life of William IV. from an assassins blow, we believe at Ascot Heath. The first is Childs, the second Banister, and for preserving the monarch the latter received £40! These men are reduced to penury by Clark, without *any cause assigned.* Similar to all despotic monarchs, he crushes without mercy, and will not reason, because he has pledged himself to save the amalgamated Companies £10,000 a year. Commentary is superfluous.

This same Peter Clark contemplated reducing the wages of the engine drivers and stokers 6d. per day. This threat was communicated to these deserving men, and on the same evening forty engine drivers and stokers met after their duties were performed at Brighton, and came to a decision to resist this aggression on their rights. These spirited men proceeded, at *twelve* o'clock p. m., to the residence of Peter, and demanded an